Systems Center PACIFIC

SSC Pacific TECHNOLOGY REVIEW 2012

Systems Center PACIFIC

Capt. Joe Beel, USN
Commanding Officer

Carmela Keeney
Executive Director

Jim Fallin
Director, Corporate Communications and Public Affairs

Jerome Core
Head, Corporate Media Branch

MCC(SW/AW) Lesley Maceyak
Operations Deputy, Corporate Media Branch

Public Affairs

Patric Petrie, lead staff writer

Ashley Nekoui, staff writer

Technical Editors

Steve Baxley, News Bulletin editor
(619) 553-3825
E-mail: steve.baxley@navy.mil

Lee Hood, writer/editor

Elisha Sullivan, writer/editor

Graphics

Art Armendariz, lead designer

Norman Tancioco, design, photo

Ann Tarvin, design, photo

MCC Lesley Maceyak, publication design

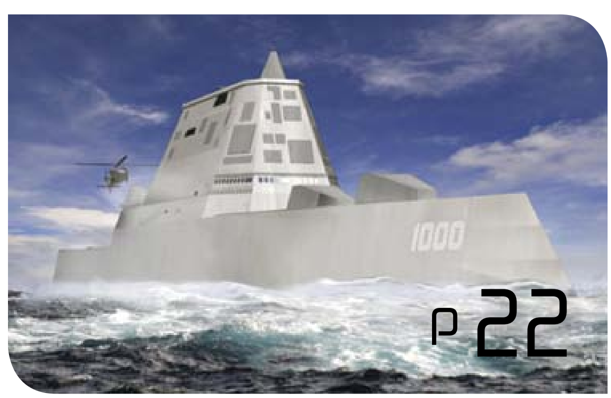
Photography

Alan Antczak

Video

Aaron Lebsack

Address correspondence to:
Code 553, Corporate Media Division,
SSC Pacific, 53560 Hull St.,
San Diego, CA 92152.



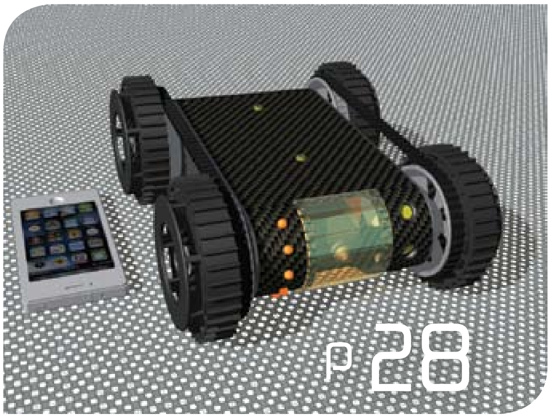
CONTENTS

TECHNOLOGY REVIEW 2012

Introduction

Information Dominance

Lab to Warrior



From the
Commanding Officer and Executive Director

The Navy's emphasis on Information Dominance in today's warfighting environment is a clear imperative! Likewise, SPAWAR's leadership in delivering major acquisition programs such as Consolidated Afloat Networks and Enterprise Services (CANES) and executing our charter as the Navy's single IT Technical Authority are central to the Navy's ability to meet the growing mission requirements as America's Global Force for Good.

This second annual Technology Review magazine highlights a few of the many cutting edge technologies you, SSC Pacific scientists and engineers, are creating for America's warfighters. Each example demonstrates the agility, commitment, creativity and leadership of our workforce.

The wide range of warfighting capabilities being addressed include:

- Information and network assurance
- Future wireless shipboard communications
- Remote energy transfer and saltwater batteries
- Reducing the size and increasing bandwidth of shipboard antennas
- Advanced sensors for next generation ships
- Advanced robotics with enhanced autonomy

The demand for our expertise has never been higher, and the impact of our work has never been more directly felt by warfighters! You can be justifiably proud of your efforts serving the Nation and our Navy.

The demand for our expertise has never been higher, and the impact of our work has never been more directly felt by warfighters!

Joe Beel
Captain, U.S. Navy

Carmela Keeney
Executive Director

Information Dominance

Mastering today's information environment to ensure decision superiority in 21st century warfare

Navy information dominance optimizes all available information-based sensors, resources, and capabilities for maintaining an operational advantage at sea while denying adversaries free access to their own information.

SSC Pacific's information dominance mission is to gain a deep understanding of the inner workings of adversaries, develop unmatched knowledge of the battlespace, provide the Navy's operating forces with sufficient superiority in wartime command and control, and project power through and across the global network.

The Center's information dominance vision is to pioneer and employ innovative information-dominant capabilities, professionals, and systems to propel 21st century naval and joint forces with decisive warfighting advantages across the full spectrum of military operations.

In this section you will see:

Current Technology

Future Technology

MUOS

Enhancing communications for mobile warfighters

By Patric Petrie and Elisha Gamboa

THREE. . .TWO. . .ONE. . .TAKE OFF!

The U.S. Navy and Lockheed Martin launched the first Mobile User Objective System (MUOS) Satellite Feb. 24 from Cape Canaveral Air Force Station, Florida, providing improved and secure communications for mobile warfighters, including simultaneous voice, video, and data.

All U.S. military forces rely on Navy satellites for narrowband communications. The MUOS satellite is a narrowband Military Satellite Communications (MILSATCOM) system that supports a worldwide, multiservice population of users in the ultra-high frequency (UHF) band, providing increased communications capabilities to smaller terminals while still supporting interoperability with legacy terminals.

MUOS is designed to support users that require greater mobility, higher data rates, and improved operational availability.

In support of PMW 146, SPAWAR Systems Centers collaborate to provides MUOS with research, development, test and evaluation support, leadership, subject matter expertise, and contractor oversight.

MUOS adapts a commercial third-generation Wideband Code Division Multiple Access (WCDMA) cellular technology with geosynchronous satellites to provide a new and more capable UHF MILSATCOM system. The MUOS program of record includes a satellite constellation of four operational satellites, a ground control network management system, and a new waveform for user terminals.

A single MUOS satellite will provide four times the capacity of the entire ultra-high frequency follow-on (UFO) constellation of eight satellites. Each MUOS satellite also includes a legacy UHF payload that is fully compatible with the current UHF follow-on system and legacy terminals. This dual-payload design ensures a smooth transition to the cutting-edge WCDMA technology while the UFO system is phased out.

Additionally, the Program Executive Office for Space Systems (PEO Space) and SPAWAR's Competencies 5.5 and 5.7 are developing a prototype MUOS cross-link capability under the Joint Capability Technology Demonstration (JCTD) Program.

The JCTD Program, managed by the Rapid Fielding Directorate (RFD) in concert with the Joint Chiefs of Staff, funds the accelerated development and operational evaluation of mature advanced technology.

The Integrated Communications Extension Capability (ICE-Cap) is the SPAWAR initiative to develop this "cross-link" from a nano-satellite (CubeSat), in low earth orbit, to the Mobile User Objective System (MUOS) communications satellites, in geosynchronous orbit; using a WCDMA software-defined radio.

The cross-link will provide both command and control to the CubeSat as well as extended satellite communications to the fleet and joint forces out of direct range of the MUOS satellites.

This first MUOS satellite and associated ground system provide initial on-orbit capability, and will be followed by the launch of the second spacecraft in 2013. The five-satellite global constellation is expected to achieve full operational capability in 2015, extending UHF narrowband communications availability to the armed forces well past 2025. MUOS is vital to future UHF SATCOM operations and is already starting to change the delivery of communications services.

A single MUOS satellite will provide four times the capacity of the entire ultra-high frequency follow-on (UFO) constellation of eight satellites.

Advancing Remote Energy Technologies

By Patric Petrie, lead writer

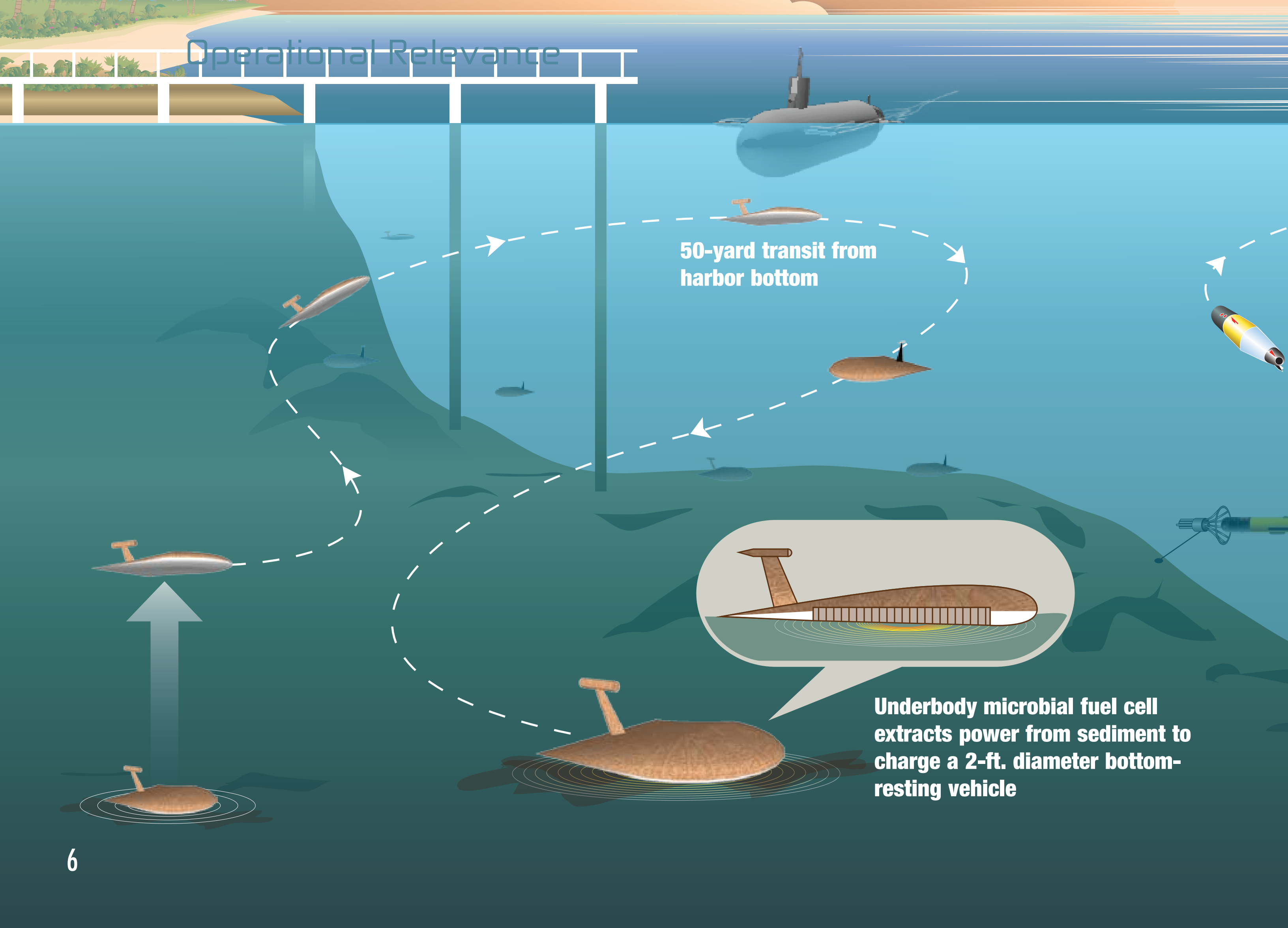
Somewhere in the world's oceans, right now, an unmanned, underwater vehicle (UUV) is covertly collecting much needed data, but its batteries are starting to fail.

In the age of "working smarter, not harder," the U.S. Navy and the Department of Defense are actively searching for operationally relevant ways to create sustainable intelligence, surveillance, reconnaissance (ISR) networks. Its burgeoning network of unmanned ISR sensor and vehicle platforms is typically powered by onboard batteries that must be recharged via traditional manned recovery methods — an approach in which operational risks and manpower costs multiply rapidly with the number and distribution of unmanned systems.

So, what if SPAWAR could create an smart phone charging station for UUVs, where the vehicle can automatically dock and recharge itself underwater, instead of having to physically recover the vehicle for shipboard recharging?

What if the energy source needed to sustain this undersea network is as conveniently close as the ocean mud floor and could be extracted using the ebb and flow of tidal currents? And what if the battery needed to store the captured energy could run on seawater?

Operational Relevance

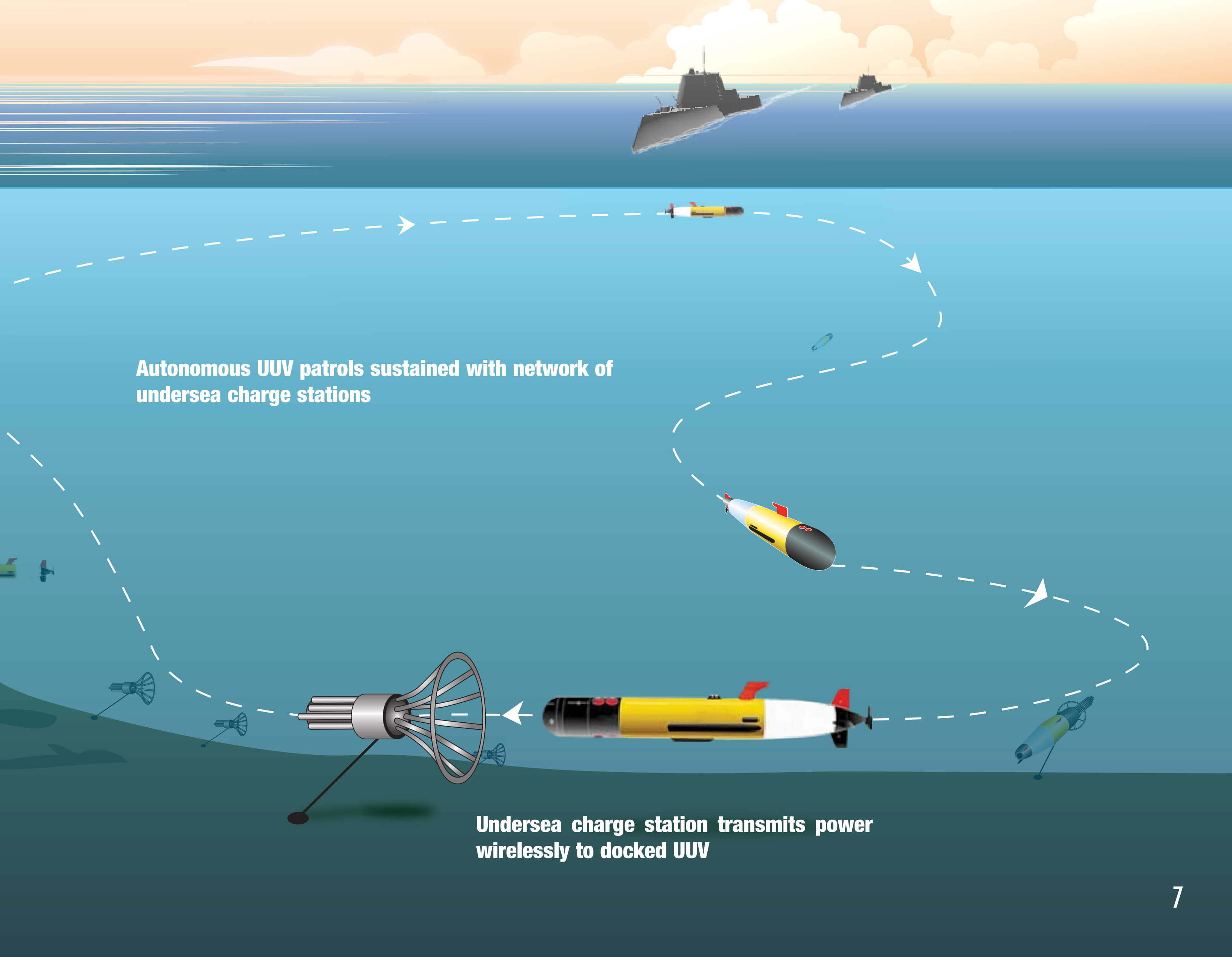


If energy could be exchanged wirelessly in seawater for downloading or uploading from ocean charging stations, then a remote undersea energy network could be formed to sustain unmanned sensors and vehicles through renewable or even planted energy sources.

"Mudfish" is an innovative SSC Pacific project designed to exploit energy from the ocean floor by integrating microbial fuel cell (mud-charging) technology in the underside of a bottom-dwelling, undersea glider vehicle. This will enable sustainable, covert, forward-deployed surveillance platforms that do not require a human presence to recharge the vehicles.

While the stealthy UUV cited above is a clear example of a solitary forward-deployed, large ISR platform in need of power, by contrast, the Mudfish is actually an example of a small "sleeper" platform that is deployed in swarms, gathers and sends data when at the surface, and then goes back to "sleep" to recharge on the mud floor. The difference between the two is that Mudfish is a much smaller, minimally mobile, less capable platform that is deployed in swarms which can sustain themselves on-site, unlike the larger UUV which must return to a charge station for energy.

Both are examples of information dominance extended through remote charging methods.



SPAWAR Technologies

SSC Pacific scientists are actively designing innovative energy platforms to meet these hypotheticals and potentially extend the Navy's mission of information dominance into remote areas by wirelessly transferring or generating power in undersea environments. To achieve a maritime energy network, researchers across the Center are collaborating to develop critical capabilities in:

- Undersea energy transfer
- Undersea energy harvesting
- Undersea energy storage

Much like commercially available wireless consumer electronics charging platforms, the Naval Innovative Science and Engineering (NISE) funded research effort seeks to use inductively coupled power transfer (ICPT) methods to upload/download energy between unmanned systems.

UUVs can upload or download energy in UUV docking stations by using inductively coupled power transfer (ICPT) methods which can transfer energy wirelessly between close proximity coils.

The challenge for the Navy is transmitting energy through conductive seawater while avoiding any potential biofouling effects. Consumer and electric vehicle applications operate in much cleaner atmospheric conditions where inductive energy is less likely to be lost to the environment.

By first modeling the effect of coil dimensions, wire diameter and transmission frequencies, SSC Pacific researchers can explore numerous design parameters to optimize power transmission through centimeter-scale gaps of seawater.

Impact

If undersea charging can be accomplished, then far-reaching strategic changes in the deployment of fixed and mobile unmanned systems can be effected.

Some examples:

- A fuel-cell or renewable energy-based docking station can replenish a rotating patrol of UUVs for harbor security or covert surveillance in forward regions.
- A UUV "fuel truck" can download energy to a network of sensors
- A UUV can harvest energy from a distributed grid of renewable energy sources that would otherwise be able to offer their stored energy only to adjoining hardwired systems.

Undersea Energy Harvesting

SPAWAR engineers are also developing hydro-kinetic oscillators to drive Kinetic Energy Harvesting (KEH) devices in low flow applications to power sensor, communications, and UUV charge platforms.

Unlike traditional offshore and structural engineering goals which seek to minimize wind and flow-driven vibrations, this SSC Pacific research aims to amplify undersea vibration effects for greater KEH power output.

Commercial power platforms simply scale up for greater flow capture, but the research focus at SSC Pacific is on how to exploit flow-induced vibration fundamentals in slow ocean currents using narrow diameter (one inch or less) cylinder oscillators.

SSC Pacific researchers have demonstrated how oscillator devices can be designed to resonate (vibrate at maximum amplitudes) at the flow excitation frequencies that result when a cylinder is exposed to threshold flow speeds.

If successful, this research will lead to compact energy harvesting devices which can be individually bundled with undersea sensors or which can be deployed as a dispersed grid of energy nodes to enable energy collection by a UUV, much as crops or fruit trees are harvested by a farm vehicle.

Mudfish

A different energy harvesting problem is encountered when covert unmanned systems (fixed or mobile) must be deployed in sensitive, high traffic regions where tidal or current flow is limited or when shallow water depths discourage tethered or off-bottom approaches (e.g., harbors, sheltered littoral waters).

In this scenario, a sediment-charged or microbial fuel cell can be implanted in the underside of a bottom resting vehicle to replenish batteries in between mission "bursts." Unlike a remote sensor or UUV operating continuously in between energy replenishments, this vehicle concept enables a "sleeper" asset which surfaces from the harbor bottom daily for brief sensor operations and then returns to the bottom for continuous, hidden recharging.

Researchers were challenged by the fact that nearly all microbial fuel cells (MFCs) are designed to be buried in the mud to power-fixed sensors. However, this SSC Pacific concept of a migrating MFC-powered vehicle requires mud-charging while resting on the sediment surface, and no restart time after separating from, and reattaching to, the mud surface.

Currently, researchers have demonstrated that a mud-filled chamber located on the sediment surface can simulate buried microbial conditions and even double the power over typical buried conditions.

If successful, this research will enable a game-changing capability in which swarms of low-cost, bottom-dwelling surveillance vehicles can be deployed to littoral waters and then continuously sustained through sediment contact alone.

Undersea Energy Storage

Lithium batteries represent well-established energy storage devices for consumer electronics, but their use in seawater environments can lead to dangerous combustions that can quickly disable unmanned platforms.

To provide a rechargeable and safer energy storage device in seawater environments, researchers are developing an aluminum-based anode battery that offers higher energy densities than lithium-ion batteries and no combustion risks when mixed with seawater.

The challenge is that seawater batteries with aluminum electrodes are commercially available; however they are not rechargeable.

Silicon-based hydrogels are currently used in lead acid batteries to prevent electrolyte spillage. Researchers currently are working on combining aluminum anodes with silicon-based hydrogels to enable rechargeable aluminum batteries.

The Way Forward

If this research is successful, aluminum batteries may become the battery of choice for ocean systems over lithium. This conversion will result in a significantly reduced risk to warfighters and unmanned systems that rely on underwater batteries, as well as allow for longer mission durations for unmanned systems.

tracking Human Vital Signs, Remotely

By Patric Petrie, lead writer

The Remote Human Presence Monitoring System (RHPMS) is designed to provide smart, passive detection of an active human (versus animal) presence using sophisticated electric field sensor technology that registers and identifies heartbeat and breathing remotely. Two SSC Pacific scientists are hard at work making the following scenario a reality today.

Imagine a coyote straying across the perimeter of a Navy base. As far as the coyote is concerned, there is no perimeter, no fence, and no obstacle as it sprints across the restricted space in pursuit of a jackrabbit. A remote sensor detects, tracks, and identifies the coyote, but no red alert goes out to security.

A few hours later, an unauthorized human sneaks through the same area. This time a red alert registers, sending out a warning to security of a suspected intruder and pinpointing the area of intrusion. The RHPMS enables immediate, accurate detection of active human presence wherever deployed.

Organizational Relevance

Passive remote detection technology can be used for a variety of short-range applications, including the remote monitoring of patient vital signs (heartbeat and respiration) of wounded warfighters in the field, searching for a covert human presence at border crossings or in shipping containers, or even locating unconscious victims trapped under rubble following a massive temblor.

A long-range version of the system, using a buried wire as the antenna, currently detects motion at distances of hundreds of feet or more for perimeter control and safety.

In November 2010, SSC Pacific's Technology Transition office was contacted by business representatives from Google, the Internet search engine. The conversation discussed the feasibility of developing remote heartbeat detection technology. The SSC Pacific researcher told the Google representatives not only was remote human heartbeat technology possible, but SSC Pacific's patent office had submitted an invention application just a month prior.

Technological Solution

The science behind the non-contact Remote Human Presence Monitoring System is based on triboelectric charging phenomena in which both people and animals are always electrically charged by Mother Nature to some extent.

The triboelectric effect demonstrates that material contact can produce electrification with another different material through friction. For example: the pumping action of the human heart and lung organs inside the chest cavity causes the outer skin to rub against the surrounding air molecules, creating triboelectricity. The electric field associated with this can be measured remotely with RHPMS sensor technology.

Amazingly, human movement can be detected remotely by the sensor system to a distance of more than ten feet.

Concurrently, it has been observed that detected signals also contain respiration and heartbeat oscillation information. The average respiration rate for adults is 15-to-20 breaths per minute. Normal adult heartbeats range between 60 to 100 pulses per minute. Since a human being has respiration and heartbeat rates different from animals, a smart system will be able to pinpoint a human signature among a variety of signals distinguishing it from animals such as dogs, horses, and deer, by assessing a database of biometric properties.

The inventors were challenged to develop a very sensitive sensor with high stability rates in an open air environment. The key to the detector's innovative development was an electronic chip that allowed for ultra-high impedance input.

Right: Scientist on left adjusts the spectrum analyzer while subject (right) is measured for remote respiration and heart beat detection with the Remote Human Presence Monitoring System (RHPMS). *Photo by Alan Antczak*

Left: View of the spectrum analyzer display used in the Remote Human Presence Monitoring System (RHPMS). Top graph shows the frequency content. Bottom graph shows the actual real time data. Notice the little blobs after the initial large pulses. They are the heart pulses which became easy to observe when the subject held his breath. The big pulses are from his breathing. *Photo by Alan Antczak*

Such ultra-high impedance input is necessary to detect small bits of charge collected from an antenna, due to a changing ambient electric field. Making the chip operationally stable is also part of the technology design challenge. Pictured above is the pre-prototype sensor unit alongside a large signal analyzer. The remote sensor unit consists of a black antenna on top of a metal box that houses the detector circuitry. The signal analyzer is used not only to observe the real time electric field signal but to observe the frequency content including human respiration rate from 0.25 to 0.33 Hertz and human heartbeat from 1.0 to 1.6 Hertz.

The RHPMS remote heart beat detection using passive electric field concept was validated by the inventors in an open office environment. One researcher sat roughly three feet from the sensor on a conference table. A baseline heart beat was obtained using a traditional blood pressure monitor with an arm cuff. After the traditional baseline heart beat measurement, the RHPMS was used to capture the remote heart beat rate for comparison.

The heart beat rate results were identical.

Way Ahead

Recently, DARPA issued a call for "Biometrics-at-a-distance," The project's objective was to demonstrate the ability to collect, localize, and evaluate physiological signals (e.g., heart rate) at distances greater than tenmeters, non-line-of-sight, and through solid objects (walls, rocks, concrete). The RHPMS may fulfill the DARPA-desired technology already.

As research continues and the monitoring system matures, scientists are also venturing into new territory: human brainwave remote detection.

Their objective is to expand RHPMS to include the mapping out of brainwave activities without the contact electrodes currently used in electroencephalogram (EEG) studies. Traditionally, the EEG test measures and records the electrical activity of the brain via special sensor electrodes attached to the head and hooked by wires to a computer.

The inventor's first challenge will be to record brain waves remotely. Their second challenge would be to interpret this data and correlate with human intent. Ultimately, SSC Pacific scientists envision a future in which RHPMS technology will be used widely in the medical and national security areas.

The ability to mapout a brain remotely would create profound advantages for the Navy and warfighters in the ever-evolving information dominance biometric identification arena. Additionally, the project's current and projected future capabilities are aligned with the Navy's mission in Electromagnetic Spectrum Management, developing a profound understanding of the electronic environment to allow for the free and rapid exchange of information no matter the communications situation, while making an adversary's usage of the same environment his greatest challenge.

Multiple
Unmanned Vehicle Control Capability
via a single OCU

The military has incorporated many robotic systems into the battlefield. A robotic system may consist of a single vehicle, unattended sensor, or multiple vehicles or sensors. The vast majority of these systems use proprietary protocols requiring the creation and maintenance of a custom (stovepipe) operator control unit (OCU) to only control a single asset type or a very limited subset of assets.

With missions ranging from improvised explosive devices (IEDs) disposal to surveillance, the systems require mission-specific control of their functionality and mission-specific information displayed to the operator. Some control units must fit in the operator's hands while others have large computational requirements and must be located in the back of a High Mobility Multipurpose Wheeled Vehicle (HMMWV) or at a central land-based location.

Modularity in software and hardware has allowed the Center to create a single OCU that controls a variety of unmanned systems.

A screenshot of an operator controlling two simulated unmanned surface vehicles (USVs) from one console. The view allows for 360 degrees of video wrapped on a cylinder as the main display of the USV video, providing the operator improved situational awareness.

In addition to auditory warnings, large flashing warning symbols appear, as referenced in the top left corner, to alert the operator to change focus from one unmanned system vehicle to another.

The image to the left provides a screenshot of an operator controlling a simulated AeroVironment Raven unmanned aerial vehicle (UAV). Google Earth is used to simulate the UAV video feed. The goal of this project is to reduce the existing two-operator system to one operator through an innovative user interface. The screen provides video in the base layer with the relative location of the UAV to its waypoints overlaid. The operator can use the controls to choose between video and a map as the backdrop. The red mound on the bottom of the screen shows the elevation of the approaching landscape relative to the UAVs elevation shown on the left-hand strip.

Working in the robotics field since the early 1960s, SSC Pacific has acquired a wealth of corporate knowledge and lessons learned. Most of SSC Pacific's robotics projects led to the creation of custom OCUs. Of these, the Multiple Resource Host Architecture (MRHA) was the most capable and flexible. This OCU was created for the Mobile Detection Assessment and Response System (MDARS) program to control both unattended sensors and mobile vehicles using a distributed architecture.

While the MRHA is scalable (elements can be added or removed to suit the needs of the installed system and it can run on one or many computers), it is difficult to expand its capabilities. For example, to control a different type of robot, monitor a different kind of sensor, or use a different map or video display, the MRHA code itself must be modified.

SSC Pacific has learned two valuable lessons: *(1) once an OCU can control one type of unmanned system it will need to be modified "just a little" to control another; and, (2) each new vehicle controlled will require extensive changes to the user interface, either due to a customer requirement or the nature of the device controlled.*

A new approach was needed to avoid time-consuming and expensive changes to a monolithic OCU to support new devices or technologies.

MOCU was designed to minimize these issues by using a modular, scalable, and flexible architecture. Modularity allows for a breadth of functionality, such as communicating in unrelated protocols or displaying video with a proprietary video codec. Modularity also allows for third-party expansion of MOCU. Scalability allows MOCU to be installed on a wide range of hardware.

MOCU also allows the user to define what information is displayed and determine what control is needed for each system. The same core software is currently used on many different projects, each utilizing these attributes in its own way.

MOCU currently controls all of the SSC Pacific developmental vehicles, including land, air, sea, and undersea vehicles, the SPARTAN Advanced Concept Technology Demonstration unmanned surface vehicle, the iRobot PackBot, and the Family of Integrated Rapid Response Equipment vehicle and sensors. ■

Weather Watch for Warfighters

By Elisha Gamboa, staff writer

Weather conditions have the ability to adversely impact naval operations both in flight and at sea, putting warfighters at risk. Weather detection is vital, allowing warfighters to precisely plan military operations, accurately assess enemy capabilities, successfully execute military missions, and ultimately protect warfighters' lives.

To address this challenge, SSC Pacific collaborated with the Naval Surface Warfare Center Port Hueneme Division Virginia Beach Detachment (NSWC PHD VB) throughout fiscal year 2011 in the successful completion of 11 installations of the Hazardous Weather Detection and Display Capability (HWDDC) system, increasing situational awareness, in turn, significantly cutting operational costs.

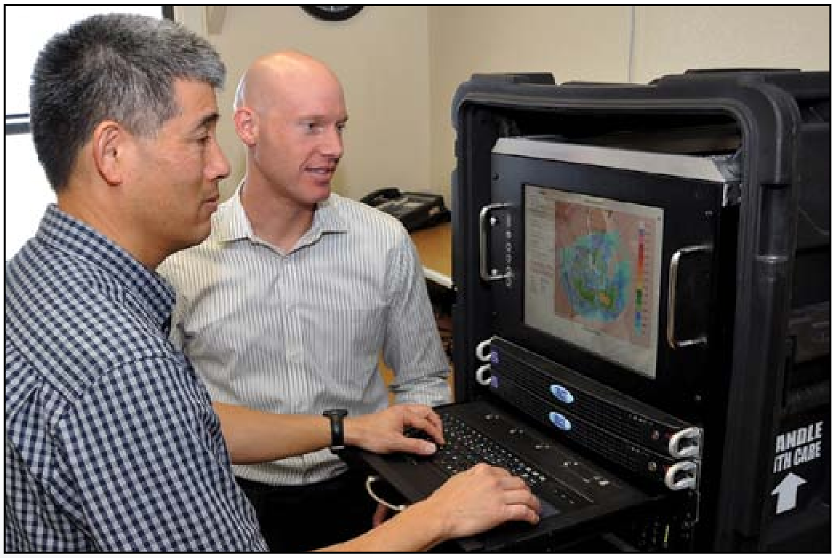
Developed by SSC Pacific's Atmospheric Propagation Branch, the HWDDC system was installed aboard six Navy Wasp-class amphibious assault ships and five Navy Nimitz-class carriers.

The HWDDC team, consisting of SSC Pacific engineers and the NSWC PHD VB Alteration Installation Team (AIT) lead, performed the installations and provided the fleet with training and end-to-end support.

HWDDC detects and displays storm location, storm intensity, rain rate, radial winds, and turbulence that are hazardous to flight operations. It performs these tasks by passively extracting atmospheric information from the tactical scans of the AN/SPS-48(E) radar installed on Navy Wasp-class amphibious assault ships and Navy Nimitz-class carriers.

An aerographer mate releases a weather balloon off of the aft end of the aircraft carrier USS Carl Vinson (CVN 70). The balloon is used to take atmospheric readings.

Photo by MC2 Joel Carlson.



SPAWAR engineers test the HWDDC. Photo by Alan Antczak

HWDDC had its beginnings in September 2001 when the commanding officer of USS John C. Stennis (CVN 74) expressed a need for onboard weather radar, and commander, Carrier Group Seven listed the need for a weather radar capability as one of his “Top 5” lessons learned during Operation Enduring Freedom.

SSC Pacific responded to this need for weather radar at sea by tasking former Atmospheric Propagation Branch members to assess the possibility of leveraging pre-existing topside radar to include weather radar functionality. Funded by PMW-120, branch members found the AN/SPS-48(E) 3-D volume search radar to be an ideal candidate in providing ships with severe weather detection capability.

By passively leveraging existing air search radar, the HWDDC system provides Navy ships with the capability to detect, locate, and display hazardous weather trends without impacting the tactical mission of the radar.

The real-time weather displays provided by HWDDC are readily available to the captain, flight operations personnel, and Meteorology and Oceanography (METOC) forecasters through the Ship’s Video Display System (SVDS) and the ship’s network.

The primary capability of HWDDC is to enhance the fleet’s readiness and ability to conduct air operations by detecting and locating hazardous atmospheric conditions that affect launch and recovery of aircraft during combat operations, rehearsals, and training events.

Prior to the HWDDC system, ships at sea based all of their weather information on forecasts, satellite imagery, and empirical data. By using the HWDDC in conjunction with the existing data collection methods, the ship is now provided with a more detailed and useful meteorological picture.

During prototype testing aboard USS Peleliu (LHA 5) in February 2005, Brig. Gen. Carl B. Jensen, commander, Expeditionary Strike Group Three, in a naval message, stated: “In an extraordinarily short time, the HWDDC’s capabilities have had a definitive operational impact during transit to AOR.

The average daily cost of a WASP-class amphibious assault ship is about $260,000. By saving a morning’s worth of flight operations, HWDDC has proved to have a considerable return on investment.

Shortly following these findings, the HWDDC project, funded by the office of Rear Adm. David W. Titley, oceanographer and navigator of the Navy and director of Navy Space and Maritime Domain Awareness, gained momentum and matured until coming to fruition with the 11 installations in 2011.

With so many benefits to the Navy, the potential for HWDDC growth is tremendous as is the potential to develop new technologies that leverage the HWDDC.

Currently, there are projects in the research and development stages that are directly related to spawns of the HWDDC and rely heavily on its data. These projects aim to further characterize atmospheric conditions that affect radar and wireless communication system performance.

The team plans to resume HWDDC installations and training in 2013 aboard the remaining Wasp-class amphibious assault ships and Nimitz-class carriers. In addition, the HWDDC has been extended to leverage the SPY-1D radar operating on Arleigh Burke class, Guided Missile Destroyers (DDG), which are also scheduled for installations in 2013. ■

Enhanced Wireless Technology

By Ashley Nekoui, staff writer

Using the design methodology developed through SSC Pacific's Multiport Antennas project, engineers have developed wideband antenna designs with increased bandwidth and a reduced footprint.

The project transitioned its algorithms to an Office of Naval Research project and will now develop the designs at SSC Pacific to support current and future wireless technologies.

Operational Relevance

For communications systems to work effectively, wideband antennas are necessary. The drawback to wide bandwidth antennas is their size; the Navy and Marine Corps lack the available space needed on the topside of their ships and vehicles to place these devices. Difficulty in placement can cause distortion in the radiation pattern.

The operational frequency of an antenna determines its physical size. As the operating frequency decreases, the wavelength increases. As the wavelength increases, so does the physical size of the antenna. When an antenna's footprint is reduced, the performance of the antenna degrades by becoming narrowband or an inefficient radiator. The Navy must develop new designs to support future waveforms and bandwidth requirements with smaller footprints for the space-limited platforms.

The research challenge in reducing the footprint lends itself to investigating new antenna design methodologies.

Antenna Characteristics

An antenna is a conductor that radiates electromagnetic energy into space or collects the energy from space. Electrical energy from the transmitter is converted into electromagnetic energy by the antenna and radiated into space. On the receiving end, electromagnetic energy is converted into electrical energy by the antenna and is fed into the receiver.

SPAWAR Role

Recognizing the competing metrics between antenna size and bandwidth, personnel from SSC Pacific's Advanced Electromagnetic Technology Branch applied for funding through the Naval Innovative Science and Engineering program to investigate if broadband performance can be achieved from narrowband antennas with different resonant frequencies using multiport impedance matching.

Impedance Matching

Impedance is the relationship between voltage and current at any point in an alternating current circuit. Impedance matching maximizes the power delivered to the antenna through the transmitter by modifying the impedance of the antenna to be a conjugate match to the impedance of the transmitter.

Description

The SSC Pacific team worked to develop a new design methodology for antennas with multiple ports. The project focused on increasing the bandwidth of traditional narrowband antennas and optimizing their radiation characteristics with multi-objective optimization.

Multi-objective optimization allows the engineer to compute the best possible trade-offs between conflicting performance objectives such as gain and bandwidth. To optimize the performance objective of gain and bandwidth, algorithms were developed to simultaneously optimize the radiation pattern and input impedance of antennas with multiple ports over a frequency range.

Figure 1. These compact antenna arrays were the first set of antennas designed to demonstrate the project's design methodology and how it may be used to design compact antenna arrays with a significant improvement in bandwidth over the current model.

Theoretical bounds were also developed to determine the best possible impedance match of a multiport antenna. To demonstrate the application of the design methodology, the antennas shown in Figure 1 were optimized, fabricated, and measured. These antennas have a small electrical footprint size and high directionality. The design methodology was then used to design compact, beam-steering antenna arrays as shown in Figure 2 for an Office of Naval Research project.

Major Accomplishments and Future Milestones

Using the design methodology developed through this project, antenna designs have been developed with increased bandwidth and a reduction in footprint. The algorithms developed through this project have been transitioned over to a current Office of Naval Research project and will now be used at SSC Pacific to support current and future wireless technologies. ■

Figure 2. The Electronically Steerable Parasitic Antenna Radiator uses the project's design methodology, allowing for its main beam to be electronically steered in four directions. The total footprint of the antenna is five times smaller than the current model in use and allows for increased bandwidth. Photo by Alan Antczak

Unique material offers new possibilities in electronics

By Elisha Gamboa, staff writer

Challenged with the need to keep up with the pace of today's rapidly evolving technology, SSC Pacific is experimenting with using new electronic materials with unique properties to provide more effective information dominance solutions, and one of its top candidates is graphene.

What is Graphene?

Graphene, a single atom-thick plane of carbon, not only has outstanding transport properties, but it also demonstrates many unique properties not found in any other high-performance electronic material. It is flexible, transparent, ultimately scalable, easily transferable to any surface, and its ambipolar conduction offers new possibilities for advanced electronics.

A two-dimensional material measured on a low temperature apparatus. Photo by Alan Antczak

Today, typical antennas operate on the concept of resonance. Resonance occurs when an antenna stores and transfers energy between two or more different storage modes. However, energy loss occurs from cycle to cycle. This loss restricts antennas substantially, causing low sensitivity, limited frequency range, and unclear channels.

Resonance also refers to the size of the antenna, and how it directly relates to the wavelength of the electromagnetic waves it detects, meaning wavelength detection is limited by antenna size.

To address these current limitations, SSC Pacific is leading the way in the research and development of grapheme-based devices.

The SSC Pacific team, in collaboration with the University of Hawaii and Massachusetts Institute of Technology, is working to develop a graphene-based photonic detector.

The graphene-based photonic detector shows promise as a compact, fast, sensitive, low-noise detector that would have the ability to operate across the entire spectrum from extremely low to extremely high frequencies, providing enhanced information, surveillance, and reconnaissance (ISR) capabilities to the warfighter.

In addition to enhancing ISR capabilities, graphene also has the potential to reduce military costs. Graphene can be made from carbon, one of the most abundant elements on earth. The material is a possible replacement for many rare and expensive electronic materials, and as a route to a host of much cheaper devices.

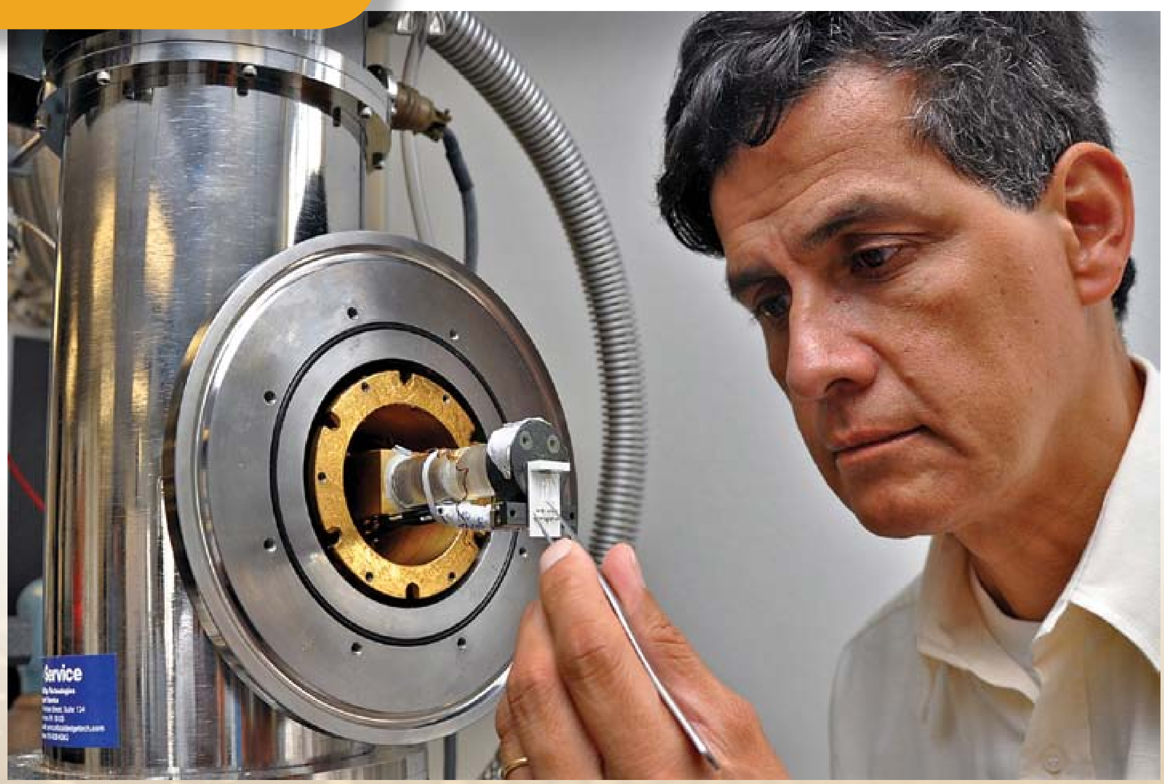
Other potential applications for graphene include:

- **Wearable electronics for warfighters**
- **Digital communications and molecule detection**
- **Satellite and space technology**
- **Lighting panels**
- **Touch screen technology**
- **Computer technology**
- **Solar cells**

In addition to graphene, SSC Pacific is also looking into other two-dimensional materials that it could possibly exploit and apply to the advancement of military technology.

The SSC Pacific team has two pending patents for the application of graphene, and is in the process of fabricating the first graphene RF detection prototypes.

Due to its unrivaled properties, the possibilities of developing novel graphene-based products for enhanced Navy warfighter capabilities are practically limitless. As further research continues on the material, SSC Pacific researchers expect emerging innovations for information dominance applications.



An SSC Pacific scientist tests a sample of another two-dimensional material.
Photo by Alan Antczak

Tactical Authentication *for Warfighters*

SSC Pacific is researching tactical authentication (TA) hardware and software to support U.S. Marines during field tactical operations.

Without proper encryption, any mission-essential information is potentially accessible by third parties. During field operations, unencrypted data sent between Marines in a tactical edge environment may be at risk of compromise.

Sub-optimal working conditions, including dust, poor weather conditions, and low bandwidth make Public Key Infrastructure (PKI) certificates and Common Access Cards (CACs) difficult to use, leaving information unsecure and vulnerable.

SSC Pacific's Tactical Authentication project is sponsored by the Office of Naval Research (ONR), and partially funded by In-house Science, Technology, and Innovation funding, to research hardware and software solutions that will enable Marines to transmit encrypted critical mission information safely and securely when CAC PKI may not be easily accessible.

A key element of information systems authentication is the process of verification of the digital identity of another party. Once that party is authenticated, the release of specific information can be authorized. Authentication, authorization, and data security, implemented through access controls, are becoming increasingly important as the Department of Defense (DoD) incorporates information assurance into its information systems.

A senior researcher sets up a Suite B tunnel between a Galaxy handheld device and a Fortress ES216 Radio. Photo by Alan Antczak

A Galaxy handheld device functions over two Suite B tunnels, Extensible Authentication Protocol (EAP) at Open System Interconnection (OSI) client manages its gateway to the Enterprise Network at SSC Pacific. Photo by Alan Antczak

Tactical communications networks traditionally employ National Security Administration (NSA)-approved, Type-1 communications security hardware that employs NSA-generated keying materials. The TA project's objective is to research, design, and implement an NSA-approved software cryptography solution to protect secret networks in a tactical, mobile, and ad-hoc network environment, without using controlled cryptographic item hardware, and obtain NSA approval via the Commercial Solutions for Classified process.

ONR's vision is to provide small-unit naval expeditionary warfighters with precise information they need, when they need it, especially in complex, hybrid warfare environments. The TA project researched several Suite B encryption solutions in search of an optimized multi-layer encryption solution suitable for tactical mobile ad-hoc networking (MANET) communications that the NSA can also approve. The project arrived at a dual-tunnel, dual-layer, multi-vendor solution using Fortress ES-210 radios, and 802.11 EAP-TLS in conjunction with a suite-B-enabled virtual private network (VPN) concentrator and client software by Aruba Networks Incorporated.

If hardware is compromised, TA provides enhanced management capabilities that can remotely disable/enable devices. The TA architecture restricts access based on permissions to different sets of data, which provides greater security and effectiveness during field operations.

TA may assist Marines in securely executing field operations when the technology is applied to a variety of critical devices, including laptops, mobile devices, and enterprise networks.

The project is now wrapping up its final year at SSC Pacific. The project is being successfully transitioned into the ONR C4 S&T project with the final transition to the U.S. Marine Corps Systems Command.

The Tactical Authentication project will undergo a 120-day certification test and evaluation (CT&E) at the National Security Administration (NSA) test facility in Baltimore, Md. Once the CT&E is completed, NSA's risk assessment will be used in the DoD Information Assurance Certification and Accreditation (DIACAP) package for the U.S. Marine Corps' designated approving authority to approve the technology for use in an operational environment.

Advanced Sensors for the Next Generation of BATTLESHIPS

By Elisha Gamboa, staff writer

For military planners, the most critical element of information dominance is information control.

Making information dominance a reality drives efforts to develop advanced technology that will enhance existing signal intelligence (SIGINT) capabilities, giving military and intelligence-driven operational forces a strategic communications advantage on the battlefield.

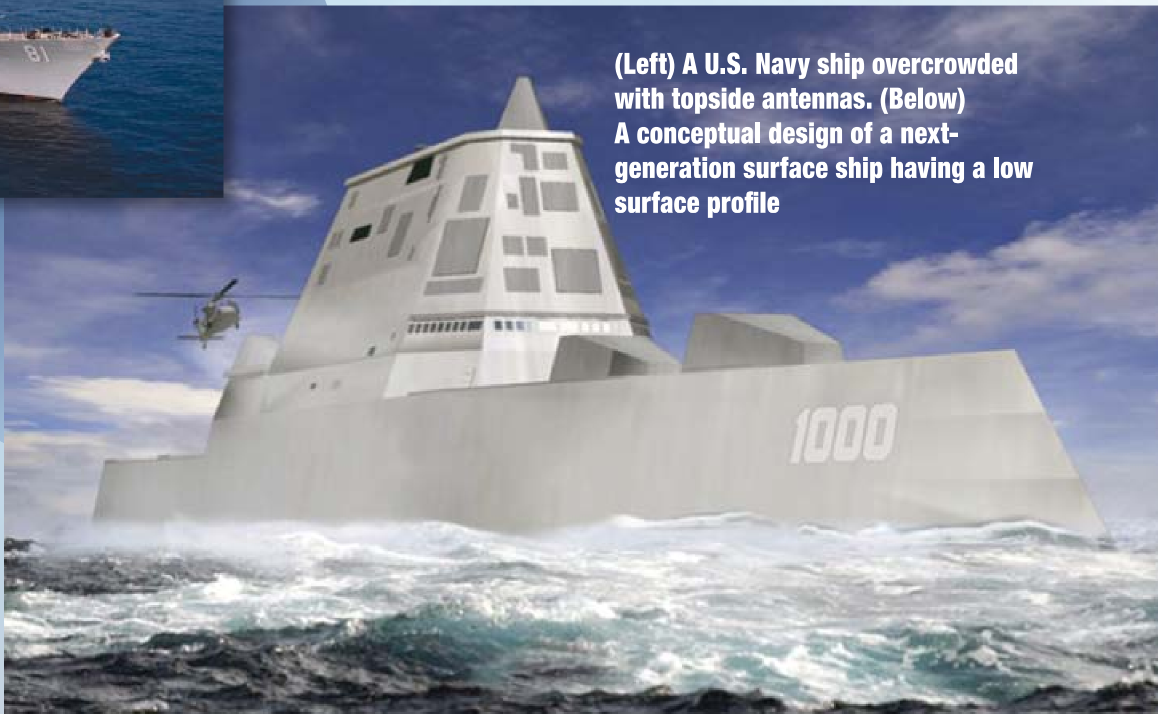
Over the years, the number of topside antennas aboard U.S. Navy ships has grown significantly, even though the space available has not. This proliferation of topside antennas interferes with the receipt of critical data, creating problems such as antenna blockage, electromagnetic interference, and increased enemy awareness of Navy combat ships.

To address these issues, SSC Pacific is working to develop a compact, highly sensitive, broadband radio frequency (RF) sensor with frequency-selective capabilities for Navy ships and other key platforms. The sensor will aid in reducing topside antenna profile, enhance existing battlefield information capabilities, and dramatically extend the SIGINT domain.

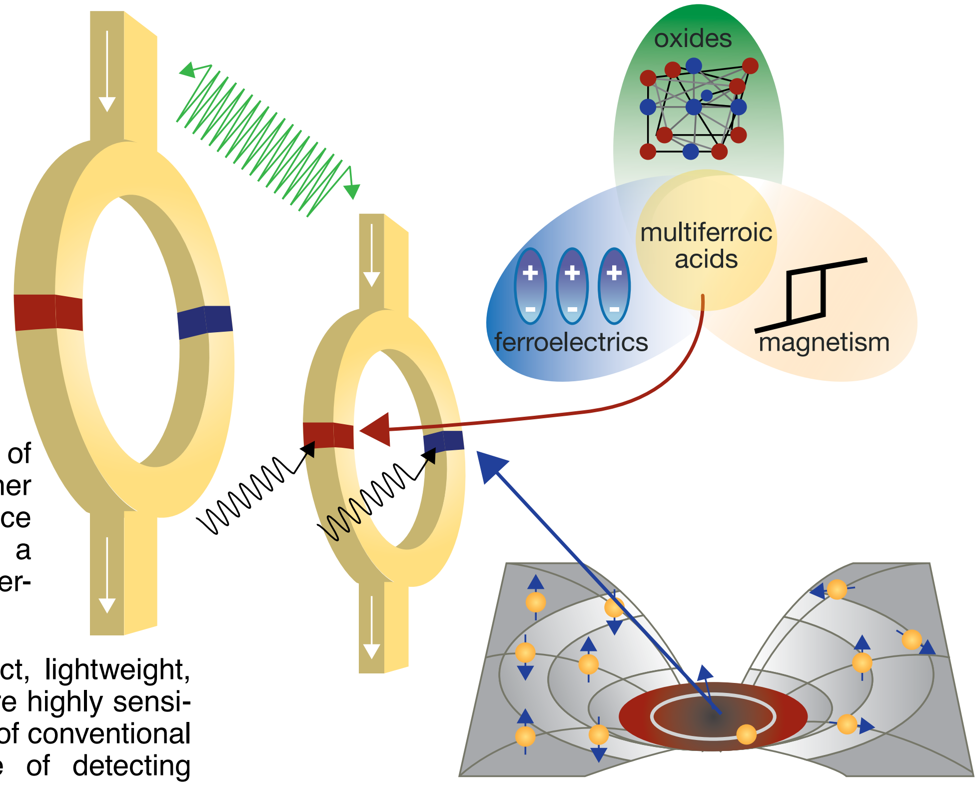
Over the past few years the SSC Pacific Cryogenic Exploitation of Radio Frequency (CERF) lab, with support from the Tactical SIGINT Technology Program, has been building a full spectrum state-of-the-art electronics and experimental device test facility. The lab is equipped to perform the rigorous characterization and certification of both inhouse and externally developed RF devices and electronics.

Additionally, the lab conducts research and development of advanced RF sensors, devices, and electronics that exploit the properties of superconducting (and other novel) materials which necessarily require operation at cryogenic temperatures.

The CERF lab has collaborated with the University of California, San Diego (UCSD) in research that is fundamental to the eventual development of a superconducting quantum interference device (SQUID) based radio-frequency (RF) sensor.



(Left) A U.S. Navy ship overcrowded with topside antennas. (Below) A conceptual design of a next-generation surface ship having a low surface profile



Depiction of a SQIF RF sensor consisting of an array of interconnected SQUIDs – loops of superconducting material having regions that form two (or more) parallel tunnel junctions typically comprised of thin insulating layers. The junctions in the device under development here would contain certain multiferroic materials (red) and/or be formed from a region of the host material exhibiting novel electronic properties (blue)

The sensor is composed of arrays of interconnected SQUIDs that together effectively perform as an interference device that is often referred to as a SQIF (superconducting quantum interference filter) RF device.

SQIF RF sensors are highly compact, lightweight, low-power receiving devices. They are highly sensitive with a noise floor well below that of conventional state-of-the-art electronics, capable of detecting nearly the entire RF spectrum. The true broadband nature and high sensitivity of the device ultimately delivers a more complete picture of events and subsequently a higher level of awareness to the warfighter, significantly enhancing command and control capabilities and SIGINT performance.

Currently, the SSC Pacific CERF Lab and UCSD are focusing on the fabrication and characterization of novel superconducting tunnel junctions that are intended to exploit complex frequency-dependent properties of materials known as multiferroic oxides. These junctions are intended to provide SQIF RF sensors a frequency-selective (FS) capability. Additionally, an investigation into tunnel junctions that can potentially exploit key electronic phenomena within the host material is also being pursued.

Supported by SSC Pacific Naval Innovative Science and Engineering (NISE) Basic and Applied Research program, the project is now entering the proof of concept stage. Ultimately, the goal is to one day field the FS-SQIF RF sensor to provide the Navy with improved, highly advanced intelligence, surveillance, and reconnaissance (ISR) of the maritime domain. ■

What is a superconducting material?

Materials that are superconductors exhibit two fundamental properties below a characteristic critical temperature.

First, an electrical current composed of superconducting electrons can be passed through the material without any dissipation of energy. Secondly, up to a certain critical value, the material completely expels all magnetic fields from its volume.

Both of these phenomena are exploited in a superconducting quantum interference device (SQUID) to form an extremely sensitive magnetic field sensor (magnetometer). Each SQUID consists of a loop of superconducting material having regions that create a weak electrical link where superconducting electrons transit through normally impenetrable regions via a quantum mechanical process called tunneling. These regions form two (or more) parallel tunnel junctions or Josephson junctions that are typically comprised of thin insulating layers. (See figure above).

What are cryogenic temperatures?

Cryogenic temperatures are typically defined as below –150 °C, –238 °F, or equivalently 123 °K.

Laser Detection and Capability

By Ashley Nekoui, staff writer

The use of lasers is becoming widespread both within the Navy and the Department of Defense for multiple warfighter capabilities, including free-space optical communications, air and missile defense, and active denial systems.

Laser-based systems can provide immunity to electromagnetic interference, and are very secure due to the high directionality and narrow beam width of laser beams.

The Navy is interested in directed energy weapons for ship self-defense and in free-space optical communication systems. Warfighters could use directed energy to transfer lethal energy directly to a target and could use free-space optical communication systems to transfer high-bandwidth data. These systems and others like them will provide advantages to future warfighters.

SPAWAR Role

To support these emerging capabilities, SSC Pacific's Atmospheric Propagation Branch's Electro-Optics (EO) group has started a project to improve laser beam off-axis detection and characterization capabilities by exploiting the properties of the interaction between laser systems and the atmosphere.

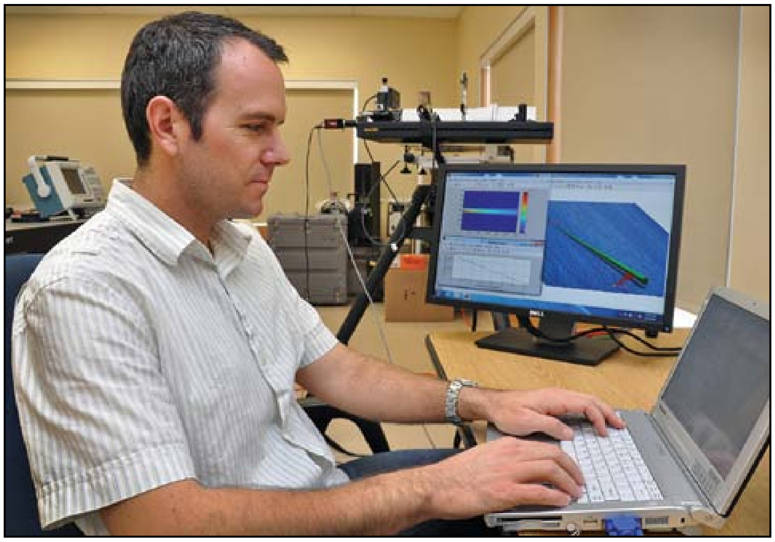
The EO group helps meet critical needs for the warfighter by developing models that predict how the atmosphere will affect propagating laser beams. For example, models developed by the group identify signal loss from laser source to receiver and thereby improve electro-optical sensors for intelligence, surveillance, and reconnaissance (ISR) and counter-ISR.

Description

The project uses the atmosphere as the scattering medium that allows for off-axis detection. Therefore, having accurate predictive models and knowledge of laser-atmosphere interaction is critical for developing the capability.

The Atmospheric Propagation Branch possesses unique capabilities for modeling maritime atmospheric conditions, providing predictions based on the local meteorological conditions. By applying these capabilities to physics-based laser-atmosphere interactions, this project is providing a step forward in laser beam off-axis detection and characterization.

The information that this new capability provides can then be further developed for signals intelligence, inform tactical decisions, and provide more insight into the performance of laser systems in the maritime atmosphere.



At SSC Pacific's Atmospheric Propagation Branch Electro Optics group works on the development of the Laser Beam Off-Axis Detection and Characterization model that simulates laser signals of off-axis detectors.
Photo by Alan Antczak

What is Laser Beam Off-Axis Detection?

To better understand what laser beam off-axis detection involves, consider a laser light show. The principles of how a laser beam can be detected off-axis are demonstrated when the colored lasers pass through the fog-like substance and are subsequently scattered from their original line-of-sight trajectory to an off-axis observer. The key process is the scattering of the laser light by the medium (in this case, fog). This redirects the laser signal, allowing it to be detected by the off-axis observer (the eye). Without the presence of the fog medium, this would not be possible.

Operational Relevance

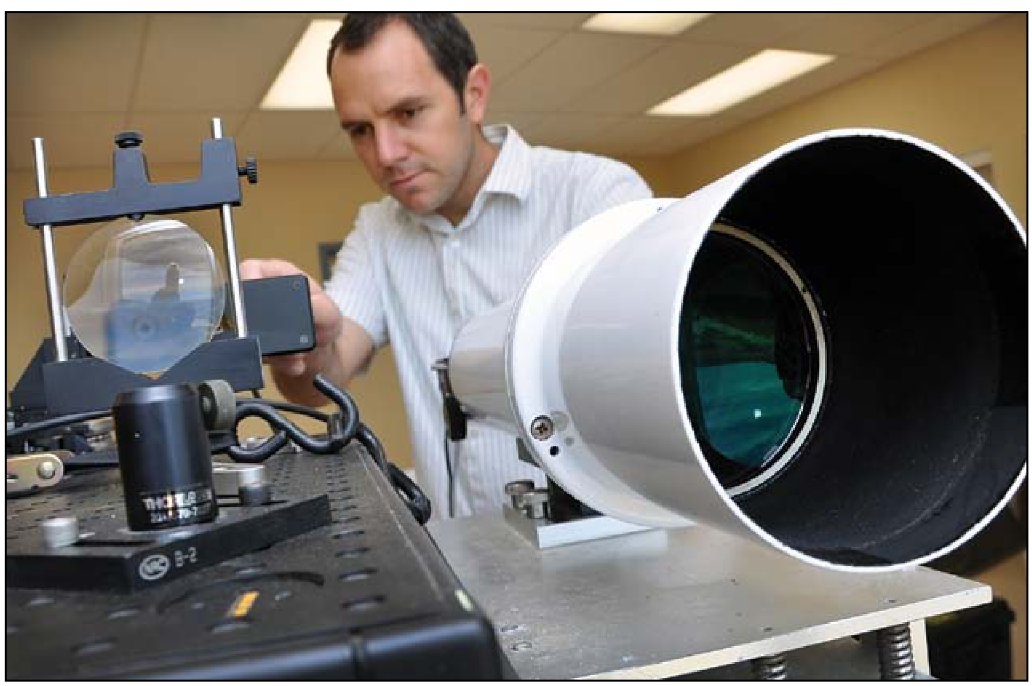
Detecting a laser source from an off-axis position will provide the Navy with information on signals not detectable by conventional technology. Additionally, it will provide opportunities for further capability development in signals intelligence and ISR.

Using this capability, and others enabled by it, the warfighter will be able to detect and characterize "point-to-point" free-space optical communication links and high-energy laser weapons.

Information is paramount to the warfighter, and employing every available piece of information contributes to ensuring mission success. This project provides an additional and increasingly critical capability for the warfighter's need to control the information domain.

Future Milestones

This project began in October 2011 through the Naval Innovative Science and Engineering (NISE) program and was recently awarded additional funding throughout fiscal year 2013. As the group moves forward into the next year of the project, they will be testing and evaluating the predictions based on the initial model and adding additional capabilities.



A scientist at SSC Pacific's Atmospheric Propagation Branch Electro Optics group adjusts receiver optics. Optics like these could be used to collect the off-axis laser signal scattered by the maritime atmosphere. *Photo by Alan Antczak*

LAB TO WARRIOR

Delivering a swift, decisive warfighting advantage to the U.S. Navy

To meet current and emerging warfighter needs and deliver future Force capabilities, SSC Pacific scientists and engineers are committed to making the Navy the most prominent and dominant service in intelligence, surveillance, reconnaissance, cyber warfare, command and control, space systems, electronic warfare, battle management, and knowledge of the maritime environment.

The Navy now recognizes the information environment as a core element of warfighting, and SSC Pacific's focus on developing warfighter capability is its driving force for pioneering, fielding, and employing game-changing capabilities to ensure information dominance over adversaries and decision superiority for commanders, operational forces, and the nation.

IN THIS SECTION YOU WILL SEE:

CURRENT TECHNOLOGY

FUTURE TECHNOLOGY

MaaS, secure mobile communications for Warfighters

By Ashley Nekoui, staff writer

The days of mobile devices being viewed as luxury items are long gone. More than half the world's population owns a mobile device, allowing users to stay connected almost anywhere in the world.

Operational Relevance

In today's high tech global environment, mobile devices aren't only used for personal use but also as a necessary tool to stay linked to the workplace. The need for secure mobile communications is directly related to naval operational mission requirements and the continuous command and control needs of our warfighters.

SPAWAR Role

Scientist and engineers at SSC Pacific and SSC Atlantic are developing Mobility as a Service (MaaS), a mobile device platform intended to provide Navy personnel with secure mobile access to Navy applications and data, anytime and anywhere. Failure to provide this capability could force warfighters to employ non-supported, incompatible, and costly systems in order to accomplish their mission.

Description

The MaaS project is pursuing the ability to provide naval information technology administrators with comprehensive control of mobile devices, applications, and data. The infrastructure is composed of a multi-platform virtual private network (VPN), as well as a device management server.

Smartphones allow Department of Defense employees and warfighters to stay connected when they are not in the office or on base.

SSC Pacific engineers are using commercial off-the-shelf (COTS) architectures to develp MaaS, and then implementing it into the cloud for added security, efficiency, scalability, and replication. The COTS architectures are a combination of servers running mobile infrastructure and device management (MIDM) software and a mobile VPN. MIDM enables the Department of Defense and SSC Pacific, in particular, to update, track, remotely lock, remotely wipe, and enforce policy to mobile devices. The mobile VPN provides a secure persistent connection from a mobile device to the desired private network using WiFi or commercial wireless networks from any telecommunication company.

MaaS provides enhanced security when compared to the current research, development, test, and evaluation wireless network and surpasses the authentication and authorization methods used for mobile devices at SSC Pacific. MaaS could enhance and increase the Navy's productivity, and support the prevention of major security issues in the ever-evolving mobile world.

Throwable Scout

By Patric Petrie, lead writer

Operational Relevance

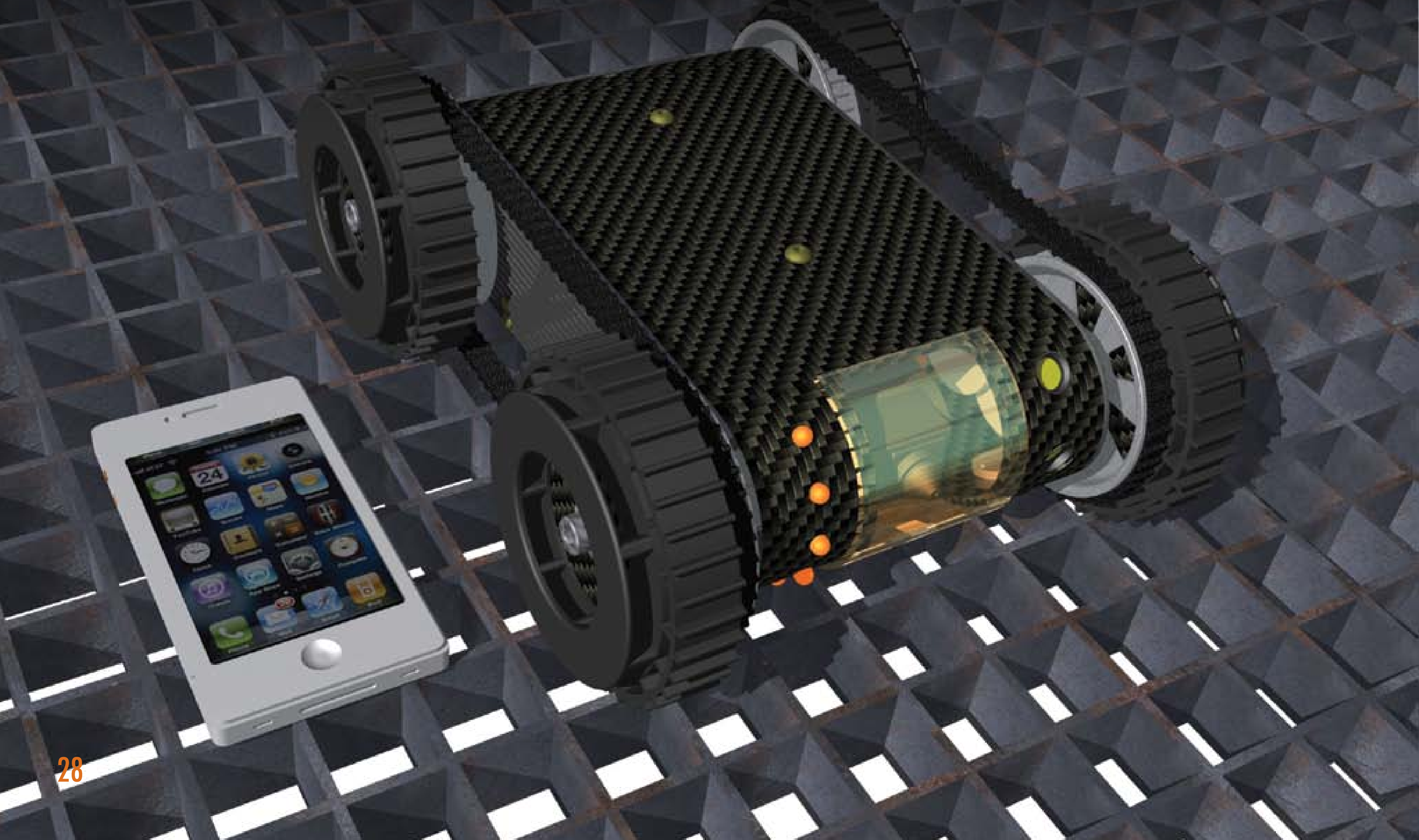
Every year the U.S. Navy conducts thousands of maritime interdiction operations (MIOs) worldwide to enforce embargoes, intercept contrabands, prevent drug and human smuggling, and fight piracy in the Navy's role as a global force for good.

Navy Visit, Board, Search, and Seizure (VBSS) teams board thousands of suspect ships, under uncertain and sometimes hostile conditions, to perform risky search operations.

Once onboard a vessel, VBSS teams quickly secure the deck and pilothouse before starting a sweep of the rest of the ship. Entering into the tight, dark, below-deck areas, with no clear line of sight and potential hazards around every corner, poses a special challenge for reconnaissance teams.

Researchers at SSC Pacific have partnered with VBSS team members to design a much needed companion for away teams, a small tactical robot that can be deployed ahead of the team to provide enhanced situational awareness during risky boarding, breaching, and clearing operations.

After a competition that tested several robot designs, the result is the Stingray. Based on the Armadillo robot already used by the military.



SPAWAR Technologies

Weighing in at three pounds, waterproof, and buoyant, VBSS teams can toss the Stingray onboard the target vessel to act as an advance scout capable of scanning and sending video back to its operator-controlled unit (OCU). If, while in transition, the robot should bounce off the side of the ship and into the ocean, the device is equipped with a steady strobe light that aids in later retrieval.

Some of the unit's unique features:

- Synergistic, relies on human operation.
- Fast, tactical penetration.
- Fast, one step ahead of the VBSS team that scoops up the robot before lobbing into the next space to be cleared.
- Waterproof, floats on surface of water, with a built-in strobe light which, when activated, allows for retrieval post sortie.
- Special tracks allow the robot to paddle on the water's surface, where its video lens can scan either sub-surface or above for potential threats. This feature is especially relevant for reconnaissance of flooded compartments.
- Sure footing on oily decks, slippery surfaces, or across deck gratings.
- Inactive Stingray can act as the team's rear guard – transmitting alert to OCU in case of rear action.
- Strobe bursts of light produce distracting and disarming enemy's vision in dark spaces.
- Supplied with a telescopic carbon-fiber pole so it can be turned into a "camera on a stick" for looking into inaccessible spaces, and it has an attachment point for a line so it can be lowered through a hatch.

VBSS operations are fast and agile. The intent is to clear and secure a space in only seconds. In most cases, the teams have no time to stop and maneuver a robot across large obstacles or door thresholds.

One key advantage to the throwable robot's design is it there is no need to navigate obstacles that can slow down clearing efforts. Instead, the Stingray can be tossed into uncleared compartments just ahead of the VBSS team, which sets the pace for the operation.

Another design advance focused on the elements of stability and traction. The average ship deck is usually contaminated with oil, dirt, or metal particles. Decks can be slanted, while vessels at sea can also experience moderate to severe pitching. Stingray's wheel design also allows it to operate on ship deck grating that often snags other small robots.

Stingray's video camera has a 185-degree field of view, and it can quickly rotate to offer a 360-degree view of a compartment. It also has an infrared light to see through the darkness of a ship's hold, plus a brilliant flashing strobe light to deploy against any enemies it encounters.

The strobe functions similarly to flashbang grenades, without the audio portion, and is reuseable. It is meant to temporarily blind the hostile personnel in a confined, dark space. Visually stunned hostiles stand far less of a chance to aim and shoot accurately, or put up resistance once the element of surprise has been lost.

A single control unit can operate two Stingrays. The one that's not being actively controlled acts as a rear guard, keeping watch and alerting the user if it sees any movement.

The Way Ahead

Two units, consisting of two Stingray robots and their corresponding command/control unit are scheduled for delivery and validation testing in January 2013. Following testing, VBSS teams may well be welcoming a new robot team member aboard to aid their continuing efforts to enforce embargoes, intercept contrabands, prevent drug and human smuggling, and fight piracy worldwide. ■

Wireless
Shipboard Communications

By Patric Petrie, lead writer

Wireless systems have been utilized to fulfill vital and non-vital voice requirements. Wireless technologies are evolving beyond traditional voice service, creating countless opportunities. The question remains, what should the Navy do to leverage wireless technologies?

Life aboard ship poses a myriad of challenges. And as wireless communications become an essential part of shipboard operations, its rapidly expanding role (and devices) is challenging the expectations of leadership and Sailors alike.

Consider these two real-life scenarios from the fleet:

Scenario 1

A pipe bursts aboard ship. Within seconds, a message indicating the situation, location, and required response is broadcast to multiple handheld wireless devices. An electrician receives the message, but as he travels the passageway to secure related power panels, he trips and becomes unconscious.

At that instant, a “man down” indication is triggered by his wireless device. Information regarding his situation and location is relayed wirelessly to damage control central. A medical response team is dispatched to the scene of the accident and the damage control team sends an alternative electrician. Meanwhile, the damage control team secures the valve that caused the burst pipe and performs required repairs.

Armed with invaluable situational information, the damage control team and the medical response team can deal with the crisis swiftly and effectively.

Scenario 2

A cargo ship runs aground, and sends out a distress signal. A Navy ship arrives on scene, rescuing the crew and bringing them aboard the Navy vessel. The cargo ship's crew is processed and visitor badges are issued. However, these badges are not your average identification cards. These badges can wirelessly track the visitors and they can also alert the ship's crew when someone enters an unauthorized area or zone.

Having this capability can provide additional security, situational awareness, and increase efficiency.

Operational Relevance

These are just two examples of how the Navy can leverage the latest in wireless communications technology. Wireless communications have been an essential part of shipboard operations for decades and wireless technologies have evolved far beyond traditional voice services, offering data solutions to meet many shipboard communications objectives. Commercial Mobile Devices (CMDs) are now at the forefront of these advancements. Multiple programs within the Navy are taking a serious look at leveraging CMDs for the expansion of wireless communications.

CMDs utilize various wireless technologies; however, when considering the procurement of these technologies, the burden of installing separate radio frequency (RF) cable and antenna infrastructures for each new technology adds concerns for the shipbuilders and acquisition community.

Currently, shipboard wireless communications systems require separate antenna infrastructures to support "free roaming" for mobile communications. With the demand for additional wireless capabilities, additional infrastructures will be required to support each of these systems, mandating higher costs for life cycle support and maintenance, as well as increased space, weight, and power restraints. In addition, as more wireless systems are added in the future, the likelihood of interference increases based on the requirement for additional wireless emitters working within the same frequency bands.

Technological Solution

The Common Optical Distribution Architecture (CODA) is designed to create a common single infrastructure to provide coverage for all shipboard wireless technologies. CODA explores the feasibility of utilizing a single, common antenna system to incorporate multiple wireless RF technologies into a scalable antenna infrastructure for shipboard use while reducing cost, weight and power requirements. This technology will also allow for the exploration of new wireless technologies to support future shipboard requirements.

The Way Ahead

While rapidly changing technological advances outpace the infrastructures supporting them, the Navy is interested in utilizing CMDs to demonstrate how fleet warfighters can more effectively use these new technology applications in day-to-day operations.

With various programs seeking to utilize wireless CMD devices onboard ships which operate on various frequencies, a common infrastructure that can accommodate these deployments is desired. With CODA, a ship can utilize a single antenna RF infrastructure which could accommodate multiple wireless services and allow for future expansion of services with minimum cost for upgrades versus replacing an antenna infrastructure each time a technology or frequency requirement changes. This is projected to save the Navy millions of dollars in infrastructure costs, while enabling SSC Pacific efforts to advance information dominance, lab to warrior, and C4ISR capabilities.

Wireless technology is at the forefront of these advances. An approach to "future-proof" these infrastructures and to allow multiple wireless services to coexist on a common RF infrastructure will allow the warfighter both the benefits of current technology while extending its capabilities for the warfighter of the future.

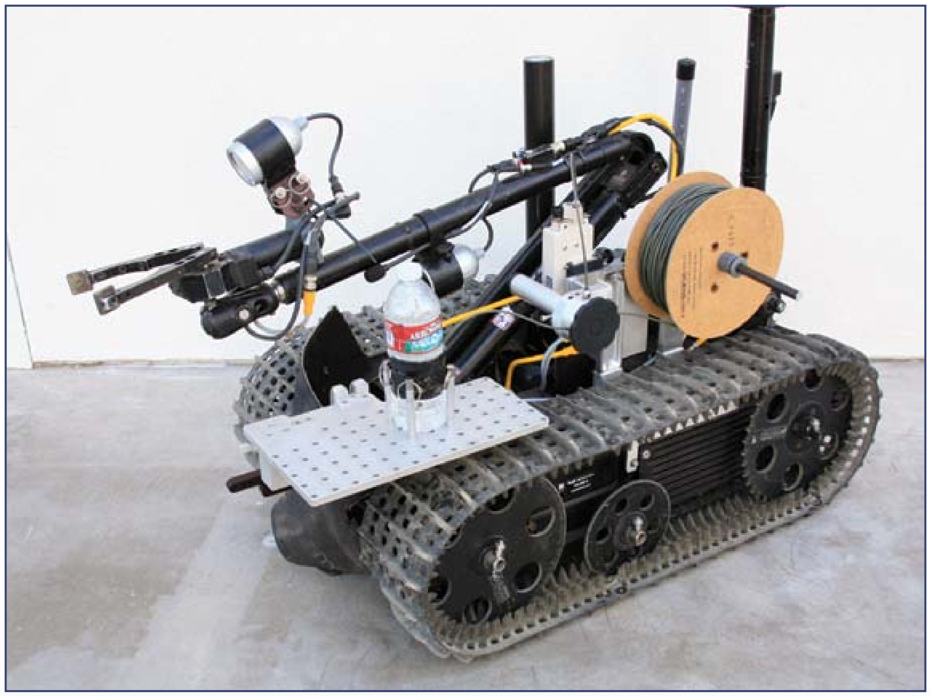
SSC Pacific is currently testing and evaluating CODA to satisfy proof of concept requirements for its potential wireless technology transition to the fleet. ■

EISS: Rapid Solutions for WARFIGHTER Needs

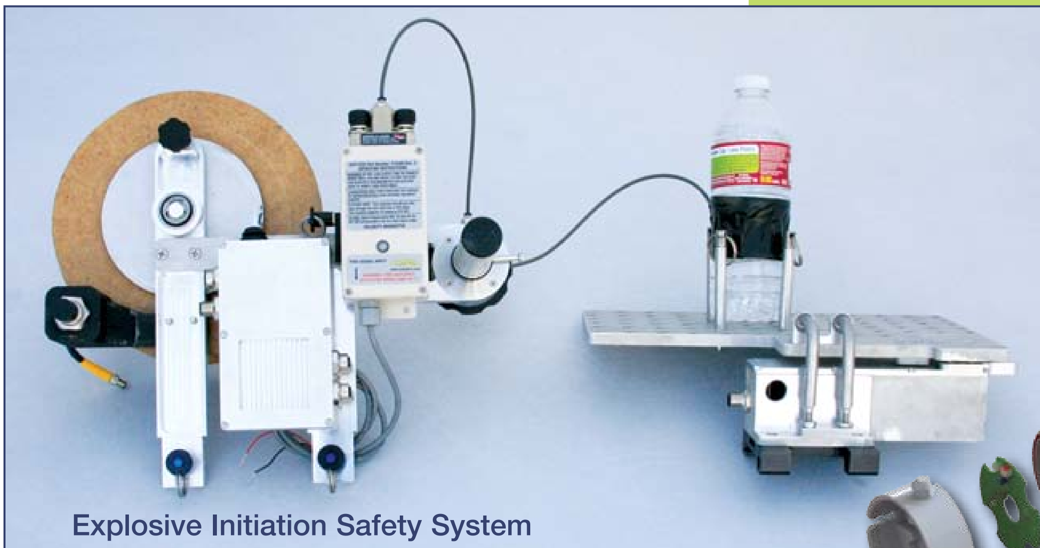
By Elisha Gamboa, staff writer

Improvised explosive devices (IEDs) are a major threat for military forces and civilian populations worldwide. SSC Pacific is countering this threat through continuing improvement of explosive ordnance disposal (EOD) robotic systems, which can now detect, detonate, disrupt, and remove IEDs with much less danger to U.S. troops.

As threats evolve and warfighters prepare for missions in new areas of operation, SSC Pacific's Unmanned Systems Group provides rapid prototyping solutions to meet emergent needs. One recent example is the Explosive Initiation Safety System (EISS) for EOD robots. Such robots often carry disruptive charges in their grippers to place on suspected IEDs for subsequent neutralization.



A simulation of being hit by a improvised explosive device in an mine resistant ambush-protected vehicle in Al Asad Airbase, Iraq. Photo by Spc Gary Silverman



Explosive Initiation Safety System

Interrupter

- Provides safe or armed indication to operator
- Arms, cuts to length, and ejects shock tube

Current operational tactics require the robot to drag a considerable length of shock tube (a fast-burning fuse for setting off the charge) from the operator's station to the IED location downrange. Such a dragging technique can cause the shock tube to become tangled in the robot's tracks or be damaged by nearby obstacles, either of which adversely impacts the mission.

Developed by SSC Pacific, EISS is a modular system that significantly enhances operator safety and tactical flexibility by providing existing EOD robots with remote connection, remote arming, and remote jettison of the shock tube while placing the counter charges.

This new approach allows the robot to place and arm a counter charge at the IED location without a shock tube-link all the way back to the operator. Once the charge is initiated by radio command, the system ejects the spent shock tube from the robot, eliminating it as an operational hazard that can endanger the vehicle's mobility.

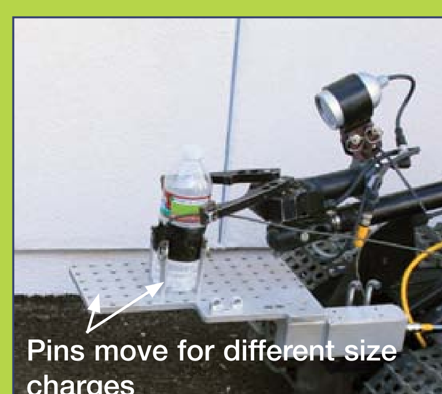
The SSC Pacific Robotics team completed assembly and testing of subsystem functions in September 2012. Testing and demonstration results will be presented to the Naval Explosive Ordinance Disposal Technology Division, Marine Corps Experimentation Center, Army Rapid Equipping Force, and Ft. Leonard Wood Engineers School, to facilitate transition to the warfighter. ■

Charge Carrier

- Allows manipulator to remain free for interrogation tasks
- Able to carry different sizes and shapes of charges

Stowed Position

Deployed Position



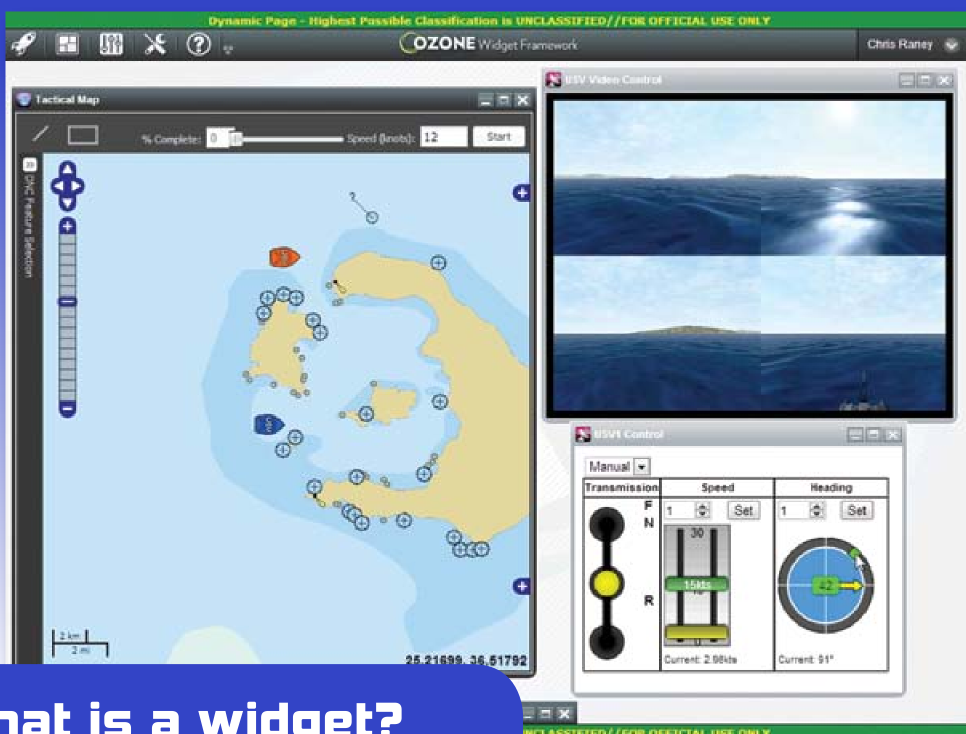
Pins move for different size charges

NISE Promotes Workforce Development

By Ashley Nekoui, staff writer

The Naval Innovative Science and Engineering (NISE) program was established in 2009 as a result of legislation passed through the National Defense Authorization Act. NISE funds basic and applied research, transition of technologies, workforce development, and recapitalization efforts at defense laboratories.

Since the program's inception in 2010, SSC Pacific personnel have submitted proposals for projects funded in areas that meet NISE program requirements.



(Left) This graphic provides an example of what an operator might view when using specific widgets to operate an unmanned system. The operator is given several different components/ options on one screen.

What is a widget?

Widgets are rich, lightweight, portable, Web-based applications typically providing visualizations (pictures, graphs) of data. They are dynamic and interactive, allowing users to make better real-time decisions. Widgets allow existing systems to break down (de-couple) their capabilities into a set of widgets. Users can then use a widget to access these capabilities from a browser.

SPAWAR Role

In early 2012, SSC Pacific proposed a NISE project that would promote workforce development across multiple SSC Pacific competencies.

SSC Pacific leadership selected personnel within the Command and Control, Communications and Networks, Information Assurance, and Research and Applied Sciences competencies at SSC Pacific to develop a project that related to their respective areas of expertise: unmanned systems, widgets, and the Cloud.

Description

The cross-competency team came together to develop a common capability it branded “Unmanned Vehicle Data to the Cloud via Widgets.” The project’s focus was to develop technology that would demonstrate tactical control of unmanned systems with a Web browser from the Ozone Widget Framework, which is a framework for visually organizing and laying out widgets within a user’s browser.

The team accomplished this task by breaking up large unmanned vehicle’s control applications into smaller components displayed by widgets. Conceptually, an operator, located anywhere in the world can access and control the unmanned system from the widgets.

The movements and views of the unmanned system are captured and stored within the Cloud, to be retrieved and visualized by local and remote operators. Having the imagery stored within the Cloud allows personnel to access the data from unmanned systems easily.

Operational Relevance

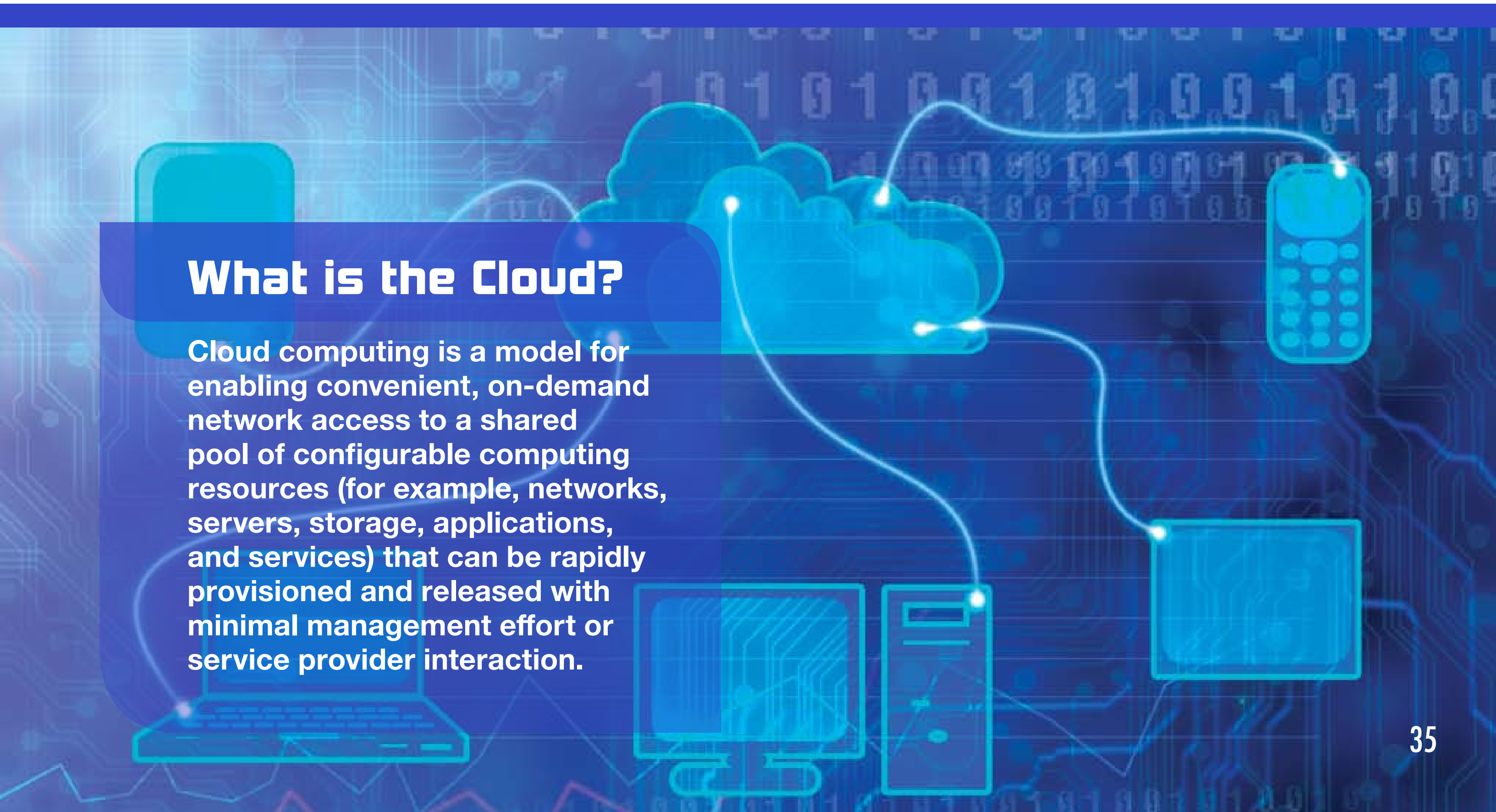
This project aligns with principles defined by the deputy chief of naval operations for Information Dominance, to reduce manning, transition to autonomous systems, and enable a single operator to control multiple platforms.

The project also addresses the Program Executive Office for Command, Control, Communications, Computers, and Intelligence’s (PEO C4I) call for rapid fielding of capabilities to satisfy existing and emerging warfighter needs and facilitate the migration of these capabilities to the Cloud.

SSC Pacific personnel leveraged existing architectures and technologies proven to support the vast amount of data from unmanned systems, where traditional database tools would not suffice.

Future Milestones

The team achieved its project goals during its first year. Learning from one another and expanding its knowledge base, each competency has requested more NISE funding to focus on expanding the cross-competency venture. The teams will continue to enhance and refine the capabilities developed, including security, collaboration, video, and large-scale data analytics.



What is the Cloud?

Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (for example, networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

In-House Research

Conducting research to provide warfighter capabilities.

By Lee Hood, writer/editor

In-House Laboratory Independent Research (ILIR)/ In-House Applied Research (IAR)

Recognizing the essential role warfare centers and Navy laboratories play in creating, integrating, and transitioning new critical capabilities to the fleet, the Office of Naval Research (ONR) has long funded in-house research and development (R&D) programs executed by SSC Pacific.

The In-House Laboratory Independent Research (ILIR) and In-House Applied Research (IAR) programs annually execute an average of 20 individual R&D projects that span the command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) capabilities needed to make the Navy's information dominance vision a reality.

ILIR and IAR projects at SSC Pacific are executed by technical personnel and leaders in all of the technical competencies, providing an expertise that is critical to Information Dominance in the warfighting effort. Experts propose projects based on their knowledge of cutting-edge R&D needs and current work loads, and chosen through independent technical review panel evaluations and leadership vetting.

The projects described here provide a small sample of the broad range of capabilities in development through the ILIR and IAR programs.

2012 Program Metrics

- **14** separate SSC Pacific S&T projects presented basic research results.
- **3** separate SSC Pacific S&T projects presented applied research results.
- ILIR and IAR support **3** doctoral candidates from SSC Pacific in their work, one of whom received his Ph.D. degree in FY 2012 based on work performed for the ILIR program.
- Another **5** doctoral researchers led separate ILIR/IAR projects.
- ILIR and IAR produced **2** refereed journal published papers; **5** professional society papers; **9** professional society presentations; **9** patent items; **4** other published papers.
- **6** papers were accepted for publication.
- **3** projects received honor awards.
- **7** other noted results such as admiralty briefs.
- The program received **60** proposals in basic research and heard **45** oral presentations.
- The program received **71** proposals in applied research and heard **43** presentations.

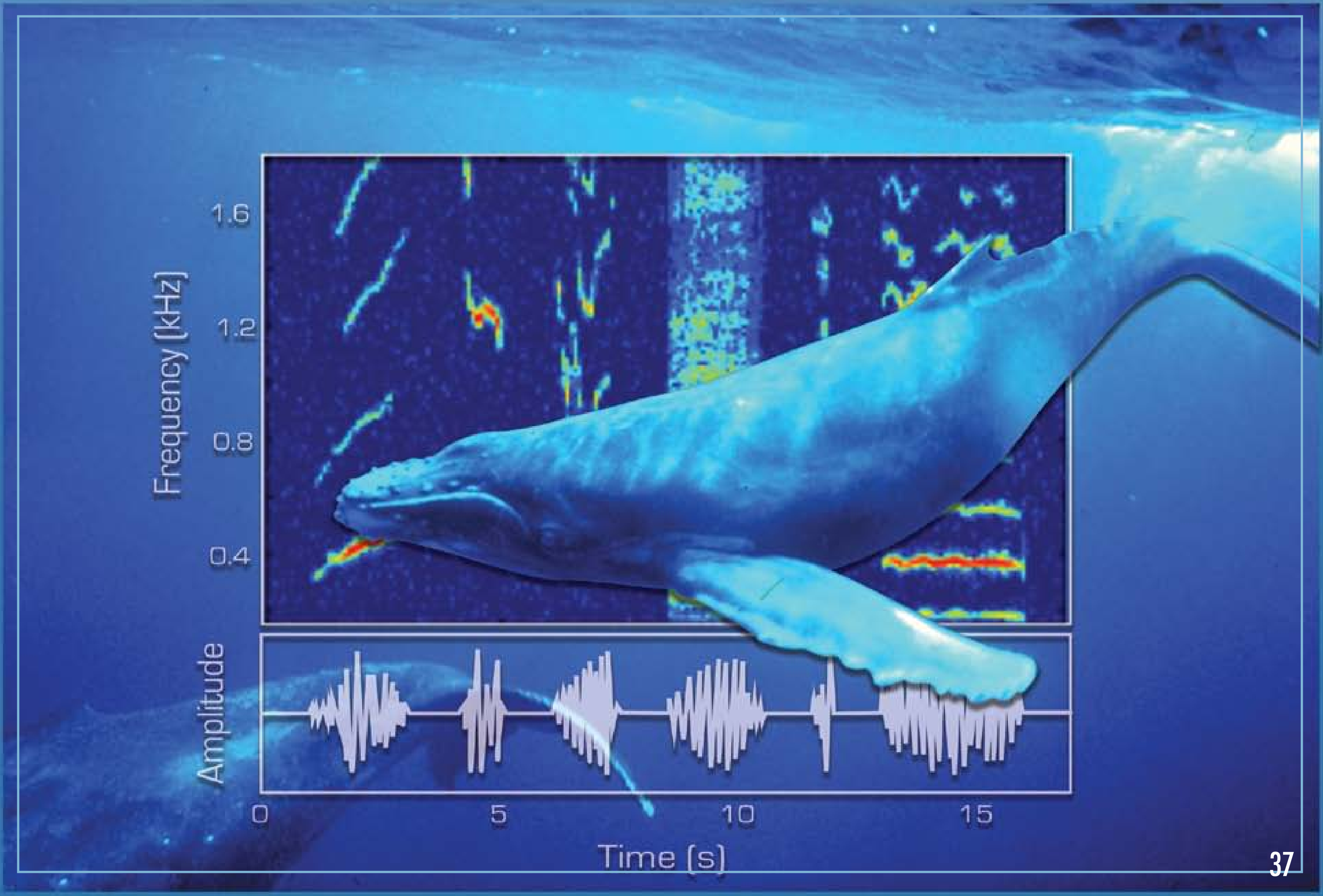
Detection, Classification, Localization, & Tracking of Marine Mammals

The Navy employs extensive mitigation measures during its training and testing activities, significantly minimizing the risk to marine mammals. Automatic detection, classification, localization, and tracking of marine mammals is critical to obtaining timely information on the presence of marine mammals.

The endangered humpback whale, for example, is particularly difficult to detect and track. Detecting humpback whale vocalizations—their songs—in acoustic data can be labor-intensive, and difficult for even trained analysts. Humpback whale songs consist of a sequence of discrete sound elements, or units, separated by silence. The units can cover a wide range of frequencies and durations, and may not repeat in a predictable pattern. Or there may be multiple, overlapping whale songs. In addition, shipping noise can "contaminate" the acoustic data.

So far, automatic detection systems haven't proven effective, with a high probability of inaccurate detections, or "false alarms." SSC Pacific researchers, working with Scripps Institution of Oceanography, have provided a solution. Researchers have developed a detection/classification algorithm that can be used to review data from long-term deployments under highly varying ocean noise conditions.

Tests show that the algorithm matches human detection performance with an acceptably small probability of false alarms for even the noisiest environments. Additionally, the algorithm can be used for other types of marine mammal vocalizations and transient signals of interest.



Visually Aided Navigation

Modern military missions depend on having accurate positioning information. GPS is the primary method to meet this requirement, but there are many situations in which GPS is not available, such as indoors, underground, in urban areas, beneath dense foliage, and in jamming environments. Dependence on GPS is a point of failure, and alternative navigation methods must be developed.

Digital cameras are one potential source of navigation information. SSC Pacific researchers developed an analytical algorithm called Visually Aided Navigation (VISNAV) for obtaining position and attitude measurements from digital cameras. They also developed an analytical method for estimating the measurement error that allows the camera's position and attitude to be blended with measurements from other sensors in an extended Kalman filter. The performance of the extended Kalman filter has been demonstrated on SSC Pacific explosive ordnance disposal (EOD) robots, which frequently operate in GPS-denied environments. Including VISNAV decreased the error of the robot's computed navigation solution threefold.

The VISNAV algorithm has been demonstrated as a valuable tool for navigating in GPS-denied environments. The current thrust of research is in evaluating other algorithms for camera-based navigation against VISNAV, and in performing incremental improvements in the VISNAV algorithm.

Predicting an Adequate Ratio of Unmanned Vehicles to Operators

Future command and control missions may employ multiple, heterogeneous unmanned vehicles (UVs) supervised by a single operator. Compared to today's operators, future operators will have to process a lot more information. Additionally, military operational planners will face a new challenge — maintaining the right workload across resources while avoiding information overload and loss of situational awareness with their operators.

Planners must be able to predict system and operator performance in order to evaluate whether a system and its crew will meet specific mission requirements. Some questions that are important to mission success include the following: ***What are the limitations and advantages of the system? Is the system adequately designed, or is it being used beyond its capacity? What is the appropriate ratio of UVs to operators for the mission?*** This project is investigating the answers to these questions through predictive computational models of operator and system performance that will allow operational planners to select and evaluate appropriate command and control (C2) technologies and determine an optimal crew size for a given mission.

SSC Pacific researchers have developed a novel test bed for new C2 technologies and a computational model of operator capacity. The test bed simulates a complex network-centric operations mission scenario to evaluate the effectiveness of different UV team sizes. The computational model not only predicts an adequate ratio of UVs to operators but also evaluates the advantages and limitations of new technologies for a complex mission scenario. Currently, researchers are collecting data to validate their operator capacity model.

Cognitive Correlators for Cyber Operations

Currently, performing robust detection and response to computer network attacks is both costly and fragile. Current cyber systems detect a portion of the ongoing threats, are susceptible to attacks themselves, and may not be maintainable in the face of future threats. Future detection systems must be smarter, more resilient, and more comprehensive. The Cognitive Correlators project addresses these concerns by creating several next-generation computer network defense and situational awareness capabilities for tactical and analytical information visualization, correlation, and prediction. The Cognitive Correlators project has integrated real-world intrusion detection systems (IDS) with new detection models and optimization strategies. During fiscal year (FY) 2012, researchers achieved several notable results.

First, using an anticipatory detection model created in FY 2011, they have shown how anticipatory feedback can be used to improve IDS performance and scalability.

Second, they have developed several probabilistic optimization strategies that provide a partial solution to cheaply increasing IDS coverage.

Third, they have created a new approach to providing computer end-users with information regarding potential threats. This approach has been implemented in a prototype named "Ambient Activity Monitors." The concept presents new methods for peripheral information awareness by exposing hidden system information in the form of visual, auditory, and kinesthetic displays.

Future work will focus on improving detection system coverage. The principal issue with anticipatory approaches is that current detection systems generally discard the information needed to anticipate future events. Improving coverage, however, requires several refinements to traditional IDS models. In particular, future systems must minimize both wasted information (i.e., discarding information that might be used for performance optimization) and wasted work (e.g., making superfluous detections). To this end, various behavioral cognitive models and cellular dynamics models are being tried as potential optimization mechanisms.

Artificial Immune System Software

By Steve Baxley, News Bulletin editor

Operational Relevance

C4ISR system operators have a difficult task. They must filter through multiple streams of information coming from many different sources and determine what information is the most important to their assigned mission.

This scenario creates two operator problems: finding enough time to watch the streams of incoming data, and trying to prevent system overload from streams of information.

SPAWAR Technologies

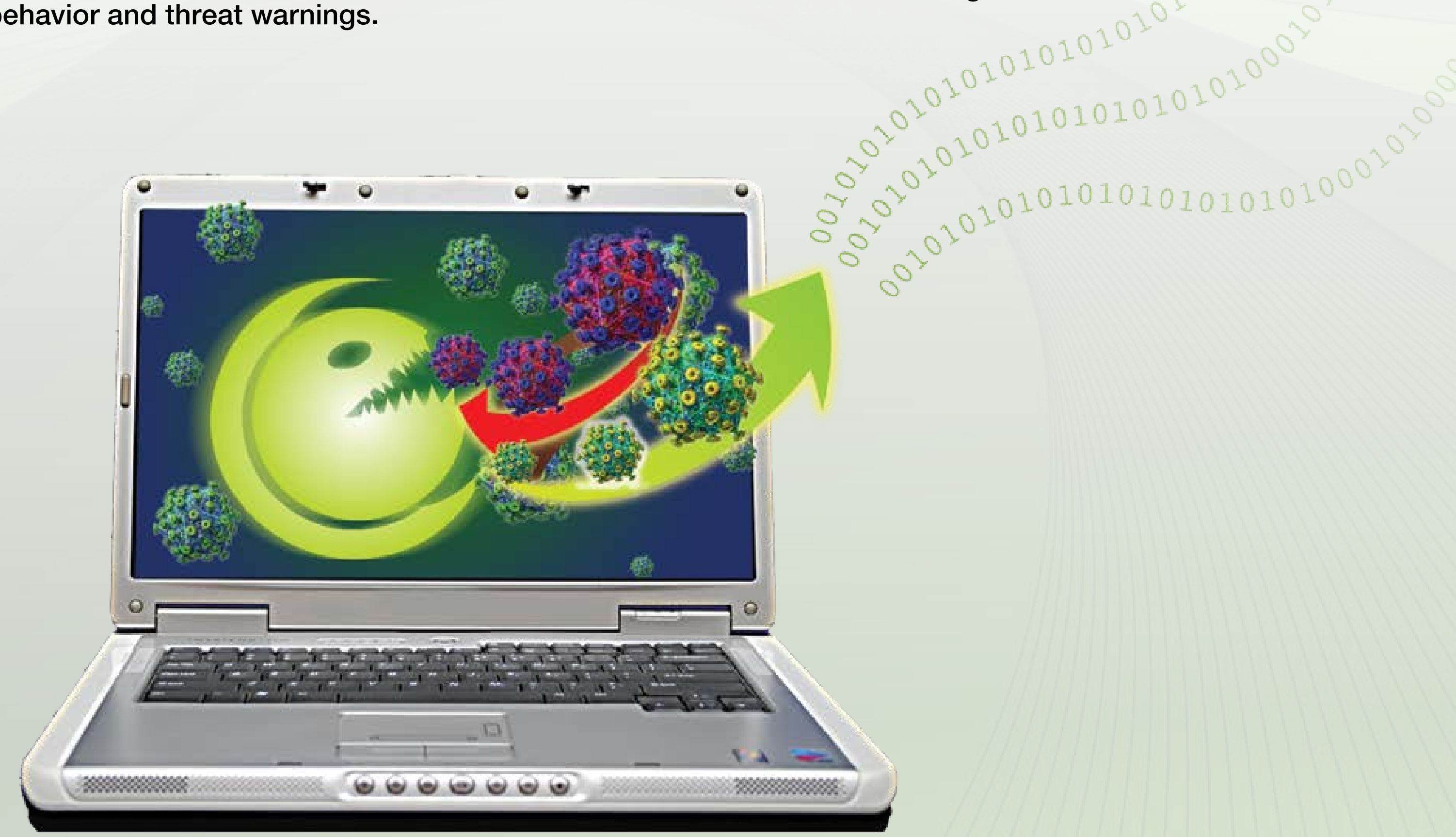
A computer scientist working on an In-house Independent Laboratory Research (ILIR) project at SSC Pacific is developing algorithms that use an artificial immune system (AIS) to mimic the immune system's characteristics of learning and memory to solve these problems.

Looking for ways to automate that filtering process, he wants to build a computer system that watches streams of data and notices indications and warnings: indications of anomalous behavior and threat warnings.

AIS is a large area of computer science, that has never been applied to a Navy operational environment. This was a chance to try something with a good track record in a new area, and the project lead thought it might have a good chance of providing some useful systems for the Navy, Marines, and the Department of Defense.

When so much data comes into a system, it bogs down. Operators can't process all the information on one system. This new system will try to split up the process of watching data by distributing the information to several systems to watch different streams of data; the systems communicate and try to learn from each other.

C4ISR operators depend on these systems to raise a warning if something odd is happening in the environment. The operator can review the alarm and determine if it is a real threat. The results of these determinations also teach the AIS to do a better job over time without increasing the operator's workload. The AIS could potentially reduce manning requirements, or catch indicators or warnings that people overlook when they are focused on something else.



Artificial immune systems are very good at examining network packets and determining those that are malicious and packets that are not threats to the system.

Historically, AIS has very low rates of false-positives and false-negatives. The environment is simple because a network packet is just a string of bits when it tries to enter a system. These systems can decide quickly and efficiently if the data is good or bad.

Trying to adapt the model that worked for network defense to a multi-intelligence data environment requires a lot of experimentation, a lot of thinking things through, and a lot of rearranging. In short, it's a lot of work. But the SSC Pacific project lead thinks AIS has a good chance of succeeding in this environment.

The AIS team has been working on the system for more than two years. The team is now building prototype systems to see how AIS works in real data environments. They have managed to get some useful data from the Marines on some of the situations that they faced on the ground in Afghanistan, and the team is using that data to test ideas and figure out how the system performs.

The goal is to develop a system that searches for complex patterns across several different data streams. The system would watch all those streams and filter those for a pattern that represents anomalous behavior or a threat. A human could perform that function if they had unlimited time and had a full understanding of all those streams.

The system evolves over time to recognize patterns. It updates itself continuously based on what it sees. If it raises an alarm, a human operator would determine that the alarm indicated a real threat or a false alarm. The system learns from that decision and continues to get better.

Ideally, the systems would be integrated everywhere, including at all the different operational levels. Each level's system would be driven by the data it receives. Each system would be different because each system would be running in a different environment.

One of the ideas behind distributing the incoming data is that one group may see a threat warning and decide it is a real threat, and that knowledge of threat patterns could be distributed to all systems.

The Way Ahead

The AIS team will design the system to cut down processing overhead by splitting up processing up and getting the systems to learn faster about what threats operators are seeing. The intent is to learn how to consume all those different kinds of information.

Time is a precious commodity for any C4ISR operator, and in an operational environment, time is not only precious, but critical to the Navy's mission of battlespace awareness and Information Dominance.

C4ISR operators in the future may rely on AIS to alert or warn them about indications of anomalous behavior or threat warnings in the Navy operational environment, saving them time for other tasks, and building a distributed system that continues to learn and effectively and efficiently arm warfighters in their battle for Information Dominance. ■

Battery Control

Extends Life of Sensors

By Steve Baxley, Daily News Bulletin editor

Applying their knowledge and experience to build the Navy's capacity to dominate the information domain, SSC Pacific scientists and engineers write proposals every year to acquire "seed money" from the Office of Naval Research (ONR) to pursue their research and development projects.

ONR releases a list of "thrust areas" it wants Navy scientists and engineers to address in their proposals, and SSC Pacific distributes this money through its In-House Applied Research (IAR) Program, and In-House Laboratory Independent Research (ILIR) Program. ONR usually provides funding for one to two years before a project must find funding elsewhere.

One thrust area this year was low-power electronics, and one of the teams chosen to work in that area was a team of three engineers at SSC Pacific.

Operational Relevance

The project used a small, 0.45-volt microbial fuel cell (MFC) to generate power for a miniature electronics package that the team may use to control sensors, rather than power them, to extend battery life.

When a sensor is continuously measuring data while powered by its own battery, the battery dies quickly. The new system could extend the life of a sensor's battery by plugging it into a low-power electronics control system, which would schedule when the sensor would turn off and on, extending the life of the battery and hence the mission.

The system's low voltage powers the electronics system, which has a special architecture unavailable in a commercial product. This is necessary due to the extremely low-voltage power produced directly by the microbial fuel cell. Though it is possible to boost the voltage level up, this inevitably leads to an increase in the size of the fuel cell.

Using a boost circuit to go from a lower voltage to a higher voltage introduces a power loss. The loss can be as low as 20 percent or as high as 50 percent of the total power delivered. To make up for this loss, the fuel cells would need to be sized larger, which defeats one of the goals of the team, namely, to make a miniaturized MFC system.

Other Center MFC teams are investigating very large MFCs approximately 10–20 meters in length, and are striving to generate one watt of power. The IAR team was interested in designing a very small system that requires very little power.

In theory, the small system would not require a diver because the device buries itself. One could take it on a boat, throw the new system overboard, and it would sink down and bury itself, avoiding the use of a diver or dredger to bury it.

The group worked with the University of Michigan because it has a sensor that works at 0.45 volts. This is not a product that can be bought. It comes from what is now an active research field. The University of Michigan is a leader in this technology with a sensor that will work at that voltage so the team can hook it up directly to the MFC.

The one-watt system generates the same voltage level as the miniaturized low-voltage system, but the one-watt system steps the voltage up from 0.45 to 5, 10 or 15 volts to power standard off-the-shelf technology.

In doing that, the one-watt system can lose up to half the power it generates. By just using direct output, allows the team keeps things small.

SPAWAR Technology

The team tried to do something that has never been done before: build a small MFC system that inherently generates low power, and use it to power a digital system with a electronic control system that can act as the “brains” for a larger system. The benefit is in the power savings gained by using this digital system as a control over standard technology.

The system is a pressure sensor, but the team used it more for the electronics control system than for the sensor, and with that electronics control system can schedule, duty cycle, turn sensors on and off, do all the thinking that a computer does, but for another sensor.

Future deployment might include use as a hydrophone listening in the water. The Navy could throw these small electronics control system devices across a body of water and they would sink to the ocean bottom. After a certain number of measurements, divers would remove the data from the system and determine, for example, how many submarines came in and out of the bay because it listened for submarines.

During FY12, the final year of the two-year R&D effort, the team implemented a flow-through test infrastructure to replicate *in situ* conditions during MFC power generation testing, submitted a patent related to the design process for MFC voltage, and integrated a micro-MFC with electronics to successfully power the electronics continuously for 49 hours.

The Way Ahead

After completing all its technical work on budget, the IAR team submitted its findings to a peer-reviewed journal.

The idea could result in a product the Navy will one day use in supporting its mission. Academia may build on the idea or move onto other discoveries. If the idea is patented, industry may partner with the Navy to build a deployable product.

When investing in research and development, the Navy has no guarantee that its investment will lead to a deployable product, but taking calculated risks are essential to ensuring the Navy and its warfighters remain at the “top of their game.”

The microbial fuel cell (MFC) flow-through system (bottom left) powers the electronics control system on the cart to the right.

UUV Compatibility Optimizing

Ocean forecast models use various sources, and Navy operators cannot always command these sources in real time as to where to take measurements. A new vehicle called a wave glider will help solve the Navy's requirement for more accurate ocean current forecasts in desired operational areas. The lack of measurements provided in the current forecast models creates a problem with forcasting ocean currents. These ocean current forecasts will also optimize the performance of unmanned maritime vehicles for long-term missions.

Wave gliders float at the surface and are propelled by a carriage that hangs 15 feet below the float. As the float moves up and down with the wave motion, the carriage's passive foils convert the up and down flow over them into forward motion of the float. Since the wave glider is always at the surface, accurate positioning and communications are maintained.

When equipped with an Acoustic Doppler Current Profiler (ADCP) and Global Positioning System (GPS), vehicle motions are subtracted from the ADCP measurements, giving accurate ocean current measurements that may be input into the forecast models.

The Global and Local Environment (GLEO) project's initial focus was on environment optimization. This involved using or developing environment information that can be applied to a Navy unmanned vehicle mission.

In the underwater vehicle environment, the main driver is ocean currents, which are applied to three main areas: improved localization in deep water (ocean current information is used to determine two-dimensional vehicle speed), advanced mission planning (using the currents to plan a mission), and real-time autonomous vehicle ocean current measurements (improve forecast models).

A new start-up evolved with optimized rendezvousing using a mini-unmanned surveillance vehicle (USV). This vehicle will use the Advanced Mission Planner software to maximize battery life, giving the mini-USV maximum range at optimum speed. SSC Pacific will use the mini-USV for remote data mining.

Using the environment to plan before and/or during an unmanned vehicle mission will increase mission efficiency (working with ocean currents to extend battery life) and success (more accurately following a desired mission path by accounting for ocean currents in planning). Of course, this all relies on the accuracy of the ocean current forecast. Forecast accuracy is increased by the number of real-time measurements made available to the forecast models.

Accomplishments

A Doppler Velocity Log (DLV) measures three-dimensional bottom track and/or water-referenced vehicle velocity and altitude. It also measures heading, pitch and roll, and temperature. SSC Pacific developed a framework to use ocean current estimates when a DVL loses bottom lock, prolonging the localization solution, which produces more accurate vehicle missions).

The Center worked with a Science, Mathematics, and Research for Transformation (SMART) doctoral intern to create an Advanced Mission Planner graphical user interface that optimizes original desired mission waypoints. to more accurately and efficiently reach the desired waypoints, This is applicable to slow-moving gliders and transoceanic unmanned underwater vehicles, which creates more efficient vehicle missions.

ADCP measurements were integrated from wave gliders into modeling/forecasting programs that produce accurate forecasts.

SSC Pacific also designed a mini-USV to optimize achieving rendezvous location arrival based on ocean current information.

Status

SSC Pacific is working further to develop the process of acquiring, converting, and importing ADCP data into forecast modeling programs. planned sea test of the Advanced Mission Planner software on an underwater glider will begin in 2013, with the goal to prove the simulations empirically. The finished design of a mini-USV optimizes range with environmental information while accurately arriving at a rendezvous location.

The SSC Pacific mini-USV is a wave glider designed to help solve the Navy's requirement for more accurate ocean current forecasts in desired operational areas.

The 'Game Changer' Autonomous Mini-UUVs

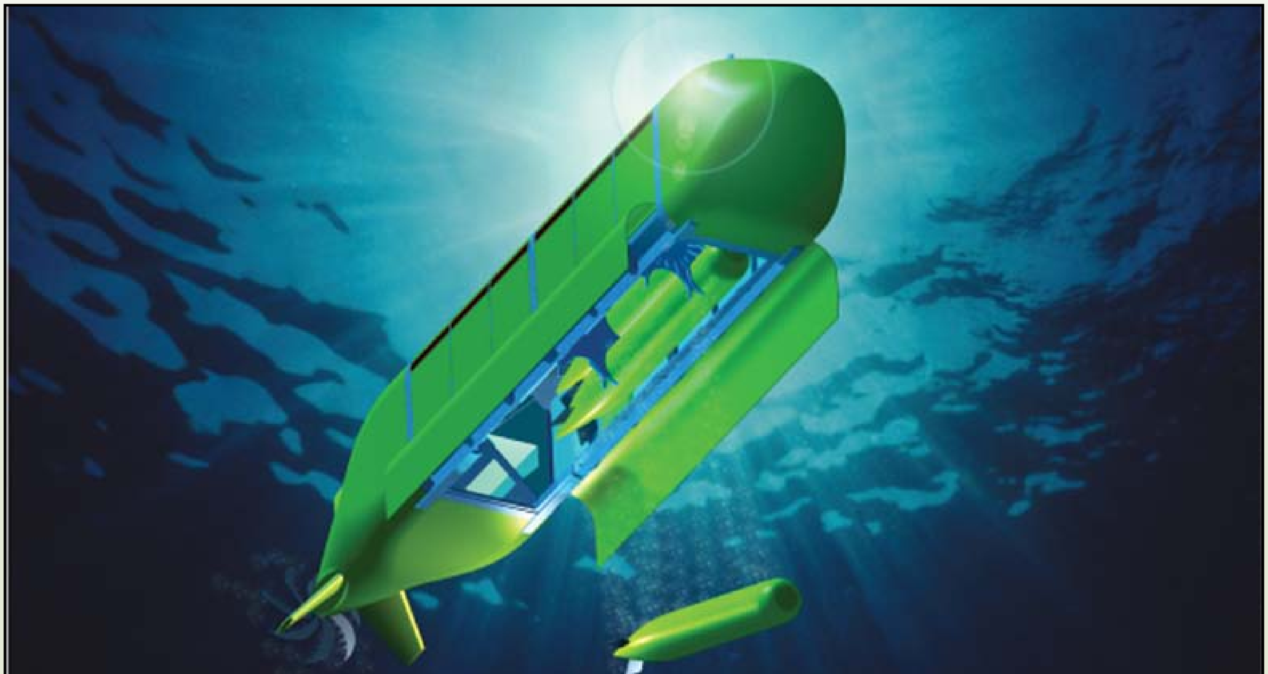
By Steve Baxley, News Bulletin editor

Operational Relevance

The U.S. Navy wants to augment its manned platform force with some game-changing technology: large, fully autonomous, long-endurance, land-launched or platform-launched unmanned undersea vehicles (UUVs) that can travel hundreds or even thousands of miles, operate near shore, and then return to their launch point.

The Office of Naval Research (ONR) program for Large Displacement Unmanned Undersea Vehicle (LDUUV) supports technology development that includes advanced air-independent energy systems and autonomy to enable months of underwater operations and sensing.

ONR fast-tracked this five-year Innovative Naval Prototype (INP) S&T program, putting several million dollars of precursory money into the program.



Conceptual drawing of a LDUUV deploying a smaller unmanned undersea vehicle.

SPAWAR Technology

SSC Pacific is responsible for the command, control, communications, computers and intelligence (C4I) that go into the mission planning and navigation for the vehicle.

The project received its mandate from former CNO Adm. Gary Roughead when he said the Navy needs large UUVs to augment its manned submarine force.

Roughead envisioned using UUVs to conduct missions such as intelligence, surveillance, and reconnaissance, as well as mine warfare, and anti-submarine warfare, tasks that submarines traditionally perform.

Current CNO Adm. Jonathan Greenert has echoed his predecessor's view on the importance of augmenting the submarine force with large UUVs.

SSC Pacific is providing environmental and situational awareness common operational picture (COP) information to the vehicle to help it make decisions on its own. The UUV will be an autonomous platform launched from a shore site, and go out to travel up to 1,000 nautical miles to conduct a mission, and then return on its own.

SSC Pacific computer scientists develop software and integrate data sources into the mission planning and navigational tools. Engineers are involved in the design of the UUV that will carry mission plan payloads.

The first test prototypes are about 25-feet long. The third prototype will be 36-feet long and about four feet in diameter.

The LDUUV is, in effect, an unmanned mini-submarine with mission payloads similar to those found on manned vehicles. The vehicle's payload bay is about 10-feet long and holds the various mission payloads. Operators can reconfigure a payload by simply placing a new payload mission package into this payload bay.

In the program's lab, computer scientists gather ocean environmental information and situational awareness information to build the vehicle's mission plan.

Engineers and computer scientists in the LDUUV Program use the same C4I situational awareness feeds for its UUV that manned Navy platforms use today. They pull in track-feeds from Open Track Manager, the software currently in the fleet. They're using OTM to create the COP that will be used to build the LDUUV mission plan.

Submerged most of the time, the LDUUV could surface occasionally and receive inputs about its area of interest.

The key elements in developing the LDUUV are power, endurance, and autonomy.

Autonomy is a huge challenge. No vehicle has been able to go hundreds of miles and avoid manmade and natural obstacles. So SCC Pacific computer scientists and engineers are working with industry and other government agencies on autonomy algorithms.

ONR wants the LDUUV to last several weeks on a mission. To accomplish this task, the vehicle must use every advantage to conserve its energy. The LDUUV program will use ocean current information to help the vehicle map its course and to save energy.

The Way Ahead

Sending a UUV on a multi-week mission is beyond anything achieved before. Most propelled UUVs are much smaller than the projected size of the LDUUV and may last hours or days. A vehicle that can transit hundreds of nautical miles across several weeks is a huge leap in technology.

ONR is investing in LDUUV development because it requires the large vehicle to operate autonomously in the littorals, automatically monitor its health, and execute its mission plans in a cluttered littoral environment.

The cost of these unmanned vehicles will be just a fraction of the cost of a manned platform, giving the Navy the means to increase its capacity.

Gathering information and performing tasks under the seas is difficult, but imagine what the Navy could do with a large number of vehicles that can go anywhere and do the same tasks that manned platforms do without risking people's lives, as well as saving time and money.

SSC Pacific computer scientists and engineers, and their partners in industry and government, are committed to making ONR's LDUUV the Navy's game-changing UUV for Information Dominance.

MDA/Aegis BMD and the Navy proved that the Aegis capability provided a unique and flexible system that is also deployable on shore.

Aegis-class destroyer USS Hopper (DDG 70) launches a standard missile (SM3), successfully intercepting a sub-scale short-range ballistic missile, launched from the Kauai Test Facility.